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CONGLOMERATE SOIL ON SOUTHERN CANAL NEAR CARLSBAD, N. MEX., WHERE MUCH WATER IS LOST BY SEEPAGE.

From such sections as this large areas of land miles away from the canal may be ruined by seepage waters and alkali, attributed directly to the loss of water from the canal.

S. 30.

U. S. DEPARTMENT OF AGRICULTURE.

Report No. 64.

FIELD OPERATIONS OF THE DIVISION OF SOILS, 1899.

BY

MILTON WHITNEY,

CHIEF OF DIVISION OF SOILS,

WITH ACCOMPANYING PAPERS BY

THOMAS H. MEANS, CLARENCE W. DORSEY,
FRANK D. GARDNER, FRANK K. CAMERON,
LYMAN J. BRIGGS.

PRINTED BY ACT OF CONGRESS.

WASHINGTON:
GOVERNMENT PRINTING OFFICE,
1900.

Set 2

To the Senate and House of Representatives:

I transmit herewith for the information of the Congress a communication from the Secretary of Agriculture, covering extensive field operations, consisting of soil surveys over various areas, aggregating 720,000 acres. In the opinion of the Secretary of Agriculture, this is the most important work of its kind ever undertaken.

WILLIAM MCKINLEY.

EXECUTIVE MANSION, *February 5, 1900.*

Set

V. P. P.—62. Tobacco—6.

U. S. DEPARTMENT OF AGRICULTURE.

Report No. 59.-72

CURING AND FERMENTATION

OF

CIGAR LEAF TOBACCO.

BY

OSCAR LOEW,

OF THE

DIVISION OF VEGETABLE PHYSIOLOGY AND PATHOLOGY.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1899.

PUBLICATIONS OF THE DEPARTMENT ON TOBACCO.

Bulletin No. 11, Division of Soils.—Tobacco Soils of the United States, a Preliminary Report upon the Soils of the Principal Districts, by Milton Whitney, Chief, Division of Soils.

Farmers' Bulletin No. 60.—Methods of Curing Tobacco (revised edition), by Milton Whitney, Chief, Division of Soils.

Farmers' Bulletin No. 82.—The Culture of Tobacco, by Otto Carl Butterweck.

Farmers' Bulletin No. 83.—Tobacco Soils, by Milton Whitney, Chief, Division of Soils.

Cultivation of Tobacco in Sumatra, by Emile Mulder.

V. P. P.—62. Tobacco—6.

U. S. DEPARTMENT OF AGRICULTURE.

Report No. 59.

CURING AND FERMENTATION

OF

CIGAR LEAF TOBACCO.

BY

OSCAR LOEW,

OF THE

DIVISION OF VEGETABLE PHYSIOLOGY AND PATHOLOGY.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1899.

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no. 59-72

LETTER OF TRANSMITTAL.

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U. S. DEPARTMENT OF AGRICULTURE,
DIVISION OF SOILS,
Washington, D. C., February 19, 1899.

SIR: In accordance with the recommendation in my annual report for 1898, approved by you, and the authorization of Congress, a comprehensive line of tobacco investigations, to extend and supplement the tobacco soil investigations of the Division of Soils, has been undertaken. The work includes the mapping of soil areas, studies in fermentation, improvements in breeding and selection, investigations of the conditions of growth and manipulation in foreign countries, and the question of supplying tobacco to foreign markets.

In examining and classifying the soils of the principal tobacco districts of the United States certain facts developed in regard to the commercial value of the crop from certain soils which could not be clearly understood or explained without a further investigation of the methods of curing, fermenting, and handling of the tobacco, and possibly also of breeding new varieties. Only in this way could the full value of the soil work of this Division be shown. As soon as it was definitely determined that the work could be undertaken, I requested the Chief of the Division of Vegetable Physiology and Pathology to detail an expert to investigate the curing and fermentation of tobacco, this work naturally pertaining to his Division. In accordance with this request Dr. Oscar Loew was detailed to carry on the investigations, and at once went to Quincy, Fla., where he spent some time during the fermentation season.

Other Divisions have also been asked to cooperate in a similar manner in other phases of the comprehensive investigation. In view of this extensive cooperation it is proposed to issue a series of reports on tobacco investigations, to which all the Divisions of the Department may contribute matter pertaining to the subject.

Dr. Loew's discovery of the real cause of the fermentation of cigar tobacco, as remarked by Mr. Galloway in submitting this report, can not fail to prove of great scientific interest and economic value, and will unquestionably modify the methods of curing and fermenting when the investigation has been carried further and the conditions and principles of the process are better understood.

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This treatise, which is more or less technical, will be followed by a more popular one giving the substance of Dr. Loew's investigations in connection with some temperature studies which have been made in the fermenting piles of tobacco in Florida and Connecticut. I respectfully recommend that the manuscript herewith submitted be published as Report No. 59 of the Department.

Respectfully,

MILTON WHITNEY,
Chief of Division,
In Charge of Tobacco Investigations.

Hon. JAMES WILSON,
Secretary of Agriculture.

LETTER OF SUBMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
DIVISION OF VEGETABLE PHYSIOLOGY AND PATHOLOGY,
Washington, D. C., February 19, 1899.

SIR: I respectfully submit herewith the manuscript of a bulletin prepared by Dr. Oscar Loew, of this Division, on The Curing and Fermentation of Cigar Leaf Tobacco. The work on tobacco has been carried on in accordance with the plan of cooperation recommended in your report to the honorable Secretary of Agriculture for 1898. The investigations have involved bacteriological, chemical, and chemico-physiological studies, and the interesting results obtained will, it is believed, open the way for further work along important lines.

The chemical work has been carried on in the laboratory of the Division of Chemistry, and we are greatly indebted to Dr. H. W. Wiley, the Chief of that Division, for facilities furnished. At Quincy, Fla., Dr. Loew received much information and valuable assistance from Mr. Henry Storm and Mr. W. M. Corry, second vice-president and general manager, respectively, of the Owl Commercial Company, which has a very large tobacco plantation at that place and which has done more than any other agency in developing the tobacco industry in Florida. We wish to express our thanks to these gentlemen for their kindness.

Respectfully,

B. T. GALLOWAY,
Chief of Division.

Prof. MILTON WHITNEY,
Chief, Division of Soils,
In Charge of Tobacco Investigations.

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CURING AND FERMENTATION OF CIGAR LEAF TOBACCO.

INTRODUCTION.

The production of tobacco adapted to the different market demand has become a prominent factor in national economy. Of particula importance is the production of superior cigar leaf tobacco. The fill leaf of a cigar must above all things have a good flavor, good arom and good burn. In the wrapper leaf, however, still other qualities com in, such as elasticity, pliability, size, shape, color, size of the vein the fineness and peculiar grain of the Havana type, and the smoot silkiness of the Sumatra.

Little is known of the chemical properties of the leaf, especially those which contribute to the flavor and aroma. It is probable that th actual amount of nicotine is relatively unimportant, and it is certai that the excellence of the leaf and its adaptation to market demand is not dependent, except in a very general way, upon the amount nicotine. It has long been known that certain of the potassium salt especially potassium chlorid, can not be used at all for the productio of high types of cigar tobacco, as they give the leaf a poor burn. It furthermore an old experience of tobacco growers that excessive nitro enous manuring tends to produce a large leaf, of inferior quality, co taining an increased amount of nicotine. If the prime object of tobac culture were the production of nicotine, as the prime object in raisin sugar beets is the production of sugar, then the rational procedu would be to furnish an excess of nitrogenous manures, but nicotin alone does not make a good cigar tobacco any more than alcoh alone would make a good wine. The substances producing the flav and aroma, therefore, although probably present in minute quantitie are much more important than the actual percentage of nicotine foun in the cured leaf.

Whitney[1] has shown that tobacco suited to our domestic cigars grown only upon certain soils and under certain climatic conditions. appears, therefore, that the leaf capable of being converted into a cig leaf through the ordinary processes of curing and fermentation mu

[1] Bull. No. 11, Division of Soils, U. S. Department of Agriculture.

possess certain characters. A fresh leaf has no specific taste, nor has it any specific odor, but the finished leaf has a sharp, saline taste and a characteristic odor.

From the time the tobacco leaf is gathered in the field until the manufacture of the cigar and even afterwards a series of highly interesting changes take place in the leaf, as a result of which the characters of the finished leaf are developed and fixed. There are three stages in these changes, viz, (1) the curing process; (2) the sweating, or fermentation; and (3) the cold sweat, after-fermentation, or aging, as it is variously called.

THE CURING.

There are two periods in the curing process: The first period, in which the cells of the leaves are still alive and induce processes of metabolism; and the second period, in which the cells have died and the chemical changes have therefore no connection with the living protoplasm. In the former period, which may last only a few days (longer with the ribs), the starch content is dissolved and the sugar formed is partly consumed by an increased respiration[1] and partly transported to the ribs, where, as Müller-Thurgau has shown, starch may be formed again. In the latter period the enzyms alone are active.

Decrease of protein.—With the consumption of a large amount of the sugar a state of inanition or starvation sets in, and the reserve protein is attacked by an enzym, trypsin-like in character, the action of which will continue after the death of the cells. A cold-prepared aqueous extract of a fresh leaf will show albumin on the addition of nitric acid and warming, while the cured leaf does not give this reaction. The reserve protein and a certain albuminous portion of the nucleo-proteids of the protoplasm will thus finally be split and transformed into amido compounds and bases, only the remaining nucleins resisting, hence the decrease of protein matter in the curing and fermentation process will stop at a certain point. Such proteolytic processes proceed not only in plants exposed to darkness, which means their starvation or inanition, but also in all cases where reserve protein must be dissolved to enable further development, as in germination or development from bulbs.

It is in full accordance with physiological principles that when cells are in want of nourishment they produce a larger amount of enzyms than when well nourished. This explains why tobacco leaves killed immediately after being gathered will show imperfections when after having been moistened they are subjected to the curing process. The enzyms that have been produced during the inanition state of the

[1] The respiration of a pile of such fresh leaves may soon lead to a considerable and even injurious rise of temperature, as in the respiration of germinating barley on the malting floor. A moderate rise is often intentionally brought on, as it hastens the curing. Sometimes this rise of temperature is called sweating, although the cause here is a different one from the true sweating, or fermentation, following the curing.

cells, however, will naturally remain active after the death of the protoplasm from starvation has set in.[1]

Considerable variation has been found in the total nitrogen content of the fresh leaves, as well as in the amido nitrogen content of the cured leaves. The amount of the former may vary in American, Greek, and German tobaccos from 2, 3, or 4 per cent to 8 per cent of the dry leaf. One-third of this and even more can turn into amido compounds in the curing process.

Regulation of heat and moisture.—Further changes, relating to color and flavor, set in with the death of the cells. However, it requires a most judicious regulation of the moisture, temperature, and ventilation of the barn where the tobacco leaves are hung up to obtain those changes which characterize cured tobacco of a superior quality. This curing process may last four weeks or even much longer.[2] When the weather is too dry all the chemical changes in the leaves come to a premature stop, but on the other hand when it is too moist the danger of mold development arises. In the former case the barns must be eventually kept closed and water introduced, while in the latter case careful application of heat may be resorted to.

An interesting experiment in curing by artificial heat has been described by E. H. Jenkins.[3] Some farmers have tried the burning of sulphur with the intention of killing the mold spores by sulphurous acid, but this requires the utmost precaution, as the leaves themselves might easily be injured and even all further action in them stopped.

Sometimes mold fungi will develop unnoticed in the stems, appearing distinctly later on, when the sweating operation has begun. All diseased leaves must be discarded before fermentation begins in order to avoid further damage by the spreading of the fungi. Tobacco growers in Florida recognize the white mold, the yellow mold, the blue mold, and the stem-rot mold, the latter being the worst and causing much damage. Sturgis has described a bacterium causing pole burn of tobacco,[4] and further determined the fungus causing the stem rot to be *Botrytis longibranchiata*.[5] Jenkins reports that the pole burn disease "may destroy a portion or even the whole of the harvested crop within forty-eight hours after the time when the trouble is first noticed."

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[1] It is somewhat difficult to prove the presence of diastase in healthy normal leaves, as very small quantities may resist extraction.

[2] The drying, or curing, for good cigar tobacco requires about as much time in America as it does in Europe. Tscherwatscheff, a Russian, has described the American method as requiring but four days with applications of artificial heat (Landw. Jahrb., 1875). What he had seen, however, was nothing but the preparation of light-colored cigarette tobacco as practiced in North Carolina, Virginia, and Kentucky. In curing cigar tobacco fire is resorted to only when damp, foggy weather prevails for a long time.

[3] Conn. Agr. Expt. Sta. Ann. Rept., 1897; *Ibid.*, 1892, p. 38.

[4] Conn. Agr. Expt. Sta. Ann. Rept., 1891.

[5] *Ibid.*, Sturgis's list of tobacco diseases.

Flavor.—The development of the flavor of cured tobacco has not yet been explained. At first a decided flavor of cucumbers[1] is generated, which later on is entirely replaced by the rank and common straw smell of cured tobacco, giving rise finally to the superior tobacco flavor developed by the sweating or fermentation process.

Color.—As regards the brown color of cured and fermented tobacco, there can hardly be any doubt that not only one but several compounds contribute by their chemical changes to its development. Of course the first supposition would be that the tannin, by being changed into a phlobaphene (a brown product), is the principal cause.[2] Thus, for example, in the autumn, when the leaves of oaks and of various other trees containing tannin die off, a brown coloration sets in. But the intensity of the brown color of the fermented tobacco leaf does not run parallel to the different concentration of the tannin in the cell systems of the leaf. A healthy tobacco leaf was placed with its base in a dilute solution of ferrous sulphate (about 1 per cent) for from twelve to fifteen hours, at the end of which time this reagent had risen to the tip of the leaf, thereby partly killing it. A reaction in the form of a black color appeared, principally in the epidermis and to some extent also in the mesophyll, but not at all in the vascular bundles. This black coloration seemed to be restricted to the chloroplasts.

The epidermis of cured leaves, however, contains the least amount of coloring matter and is sometimes entirely devoid of it, with the exception of the gland hairs, while the mesophyll cells always contain a brown substance in irregular-shaped or rounded masses. The principal part of the brown matter, however, is in the veins of the leaves and even the most minute ramifications of the vascular bundles appear to be a much darker brown than the neighboring mesophyll cells. The circumstance that the veins contain less nicotine than the rest of the leaf also militates against the view that the coloring matter is principally due to the oxidation of nicotine. However, there occurs in the veins a bitter principle that does not seem to occur in the rest of the leaf, and perhaps this may contribute to the color.

It is easy to show that several compounds contribute to the brown coloration in well-cured leaves. In the first place, much brown matter is extracted by cold water. Leaves thus exhausted will yield up another portion of brown matter to warm, dilute sulphuric acid, and finally still another portion[3] of a different chemical behavior is extracted by a warm, dilute solution of potassium hydrate.

---

[1] The expressed juice of a fresh tobacco leaf is at first without odor, but it gradually assumes that of fresh cucumbers, which later on is destroyed by putrefaction.

[2] According to Savery, the tannin of tobacco is identical with that of coffee. There exists, evidently, several kinds of phlobaphene, depending on the kind of tannin.

[3] This latter portion is a mixture of several compounds, some colorless and pectose-like, and one colored and phlobaphene-like. Twenty-five grams of fermented tobacco from Florida yielded 0.51 grams of this product. The cell membranes of the tobacco thus treated exhibit under the microscope a swollen appearance.

One author has assumed that the chlorophyll is first attacked in the curing process and destroyed, but this is not correct. The green color of the chlorophyll is in the beginning merely covered by the brown substances. In the thin samples of fermented leaves of a light-brown color green spots may frequently be noticed, and even dark-colored, freshly fermented leaves may sometimes yield a greenish solution upon extraction with strong alcohol. It is of some interest to note that the brown matters are insoluble in absolute alcohol.

Ammonia.—An interesting feature in the curing and fermenting process is the formation of a small amount of ammonia. As the green leaves contain some asparagin, the formation of ammonia might be due to a small extent to the decomposition of this amide, which readily yields ammonia and aspartic acid. But in certain tobacco crops there occur only minute quantities of asparagin. Certain amido compounds formed by decomposition of proteids and also a part of the nicotine in decomposing probably yield the principal amount of ammonia. The nicotine undergoes, in the fermentation process at least, a considerable diminution, as explained below.

The opinion that the ammonia deteriorates the quality of the product is certainly unfounded, as Fesca has correctly pointed out. It has been demonstrated by Behrens that during the curing process a part of the sulphur of the decomposed proteids is oxidized to sulphuric acid and that the amount of compounds soluble in ether decreases. The latter consist of a fatty substance and a volatile oil of disagreeable odor derived principally from the gland hairs.

The total loss of dry matter in the curing process is subject to great variation, depending mainly upon the amount of starch present at the time of gathering, as above stated. The diminution of dry matter may be as much as 40 per cent.

The principal changes in the curing process may be summed up as follows:

(1) Disappearance of starch.
(2) Formation of sugar and its partial disappearance by respiration.
(3) Decomposition of protein with formation of amido compounds.
(4) Decrease of fatty matter.
(5) Decrease of tannin.
(6) Change of color and flavor.

THE SWEATING OR FERMENTATION PROCESS.

The so-called fermentation process develops in the tobacco leaves the characteristic qualities of the commercial article. It is natural to suppose that the same agency which finishes the curing process after the death of the cells remains active during the so-called fermentation process also. The fermentation follows immediately after the curing when both are done by the grower, but where the cured tobacco is bought up by manufacturers several months may pass before it is sub-

jected to the sweating process. This operation begins when the tobacco is in the proper "order" or "case," being brought into this condition naturally on a damp day, or by an exceedingly cautious moistening, avoiding any visible water on the leaves. The amount of water applied must just suffice to bring on moderate imbibition. The total amount of water necessary to bring on a normal sweat is from 18 to 25 per cent of the moistened leaf. A portion of this water (about one-fourth) is again lost during the sweat.

The sweating of the Florida leaf in bulk requires from six to eight weeks, the original crude and rank smell of the cured tobacco being gradually changed to the proper aroma of the finished tobacco, and the glossy appearance and the texture[1] being all brought out. Light-colored wrappers require a slower and cooler fermentation than the dark-colored leaves used as dark wrappers or fillers.

Rise of temperature.—When the cured tobacco is sold by the farmer a large number of leaves are tied together at the base, forming "hands." At the beginning of the sweat such "hands" are well shaken in order to open all the foliage and admit air to every part. Then commences the moistening, when necessary, which is done by exposing the "hands," under continuous shaking, to a current of steam issuing from a pipe; by spraying with a fine spray; or by dipping, in which case the bases of the "hands" are plunged into water and shaken, the adhering water being soon drawn by capillary attraction into the leaf. These "hands" are then packed, with the butts outside, in piles 4 to 5 feet wide and 12 to 15 feet long. The rooms, which contain a large number of such piles, are kept warm, and steam passes freely from a number of pipes into the air of these rooms to secure uniform moisture, as otherwise the warming piles would soon become too dry. The temperature of these piles rises in from one to two days considerably above the temperature of the fermenting room and may reach 52° C. (126° F.) or higher. Repacking becomes necessary in from three to four days in order to check the rise in temperature and to shake out the leaves. The lower "hands" are now placed on the top and the outer ones in the center in order to give all leaves an equal chance to improve. The temperature now rises more and more slowly, the next repacking not being necessary before about seven or eight days. Altogether the piles are repacked from five to eight times. When the temperature rises too high the color or the aroma may be injured, hence frequent examinations are necessary. These examinations are made by pushing the hand into the piles, a decision being reached by the sense of feeling.[2]

Oxidation.—Tobacco manufacturers are well aware of the fact that a moderate quantity of air should gain access to the interior of the

[1] The texture, or grain, of the leaf means to tobacco manufacturers small points plainly visible on the extended leaf. It appears that these points are the bases of the gland hairs, most of which break off in the curing and sweating processes.

[2] For details relative to the treatment of the fermenting tobacco heaps the reader is referred to Farmers' Bulletin No. 60 and to the next report on tobacco.

fermenting piles and that undue pressure must be avoided in order not to diminish this access of air more than is necessary to insure an accumulation of heat. Not only are numerous little channels left naturally in the piles, but diffusion also will set in as soon as the air in the piles becomes warmer than the surrounding atmosphere.

Repeated efforts have been made to replace the sweating or fermentation process by a direct oxidation. Dr. Mew, of the Army Medical Museum of this city, assures the writer that some experiments made by him about twenty years ago to improve the cured tobacco leaf by direct application of a dilute solution of permanganate of potassium resulted in an essential improvement, the product being milder. Similar results have been recently mentioned by Kiessling.[1] In Germany a patent has been granted to the firm of Siemens & Halske for treating tobacco with ozone. However, oxidation often takes quite an undesirable turn, and the danger of destroying the aroma is quite as great, if not greater, than the likelihood of developing it by artificial means.

Losses.—Jenkins has shown[2] that the losses in fermentation are apparent in the nicotine, protein, amido compounds, nitrogen-free extract, and also, to a much less extent, in the ether extract. The loss of nicotine varies considerably in different samples and was found by Jenkins to range from one-sixth to one-half in three samples analyzed. Behrens observed in one sample a decrease of nicotine from 1.46 per cent in the cured leaf to 1.07 per cent in the fermented leaf. Dambergis found in air-dry Greek tobaccos, having from 7 to 14 per cent of water, from 2.8 to 0.7 per cent of nicotine.[3]

The question as to how much the loss of organic matter amounts to during the sweating process can be answered only approximately and by comparing parts of one and the same leaf, but a constant result will never be reached, as the nature of the proceeding in fermentation brings on differences in temperature, water content, and access of oxygen, and thus leads to variations. In the fermenting heap thick and thin leaves occur, often varying more than 20 per cent in weight for an equal surface area. Leaves grown in the shade are thinner than those exposed to direct sunlight, and in hot, dry summers the leaves are thicker and coarser than in moist, rainy seasons.[4] These conditions of course naturally influence the result.

Some tobacco manufacturers estimate the average loss during the fermentation process to be 15 per cent (organic matter and water together), while others estimate the loss of solid matter alone to be

[1] Der Tabak, Berlin, 1893.

[2] Conn. Agr. Expt. Sta. Ann. Rept., 1891.

[3] Oesterreich. Chem. Zeitg., No. 16, 1898.

[4] In the rainy season of 1891 Sumatra tobacco leaves weighed 52 grams per square meter, while in the dry season of 1892 the leaves grown on the same spot weighed 80 to 90 grams per square meter. Behrens explains this difference by the larger intramolecular spaces produced by excess of moisture (Landw. Vers. Stat., 1894, Band 43, p. 272).

Bulletin misbound; For p. 17— see section preceding title-page.

from 4 to 5 per cent. According to Jenkins,[1] the losses may be even larger. He reports that "the upper leaves, short seconds, and first wrappers lost, respectively, by fermentation 9.7, 12.3, and 9.1 per cent of their total weight. But while three-fourths of the loss in the case of the short seconds consisted of water, in the case of the upper leaves almost three-fourths of the loss was dry matter. The first wrappers lost a little less dry matter than water."

Development of gases.—The formation of ammonia can be noticed by the characteristic odor in the fermenting rooms, but the amount is not so high as one might naturally be led to suppose from the intensity of the smell. About 3 liters of air from the interior of a fermenting pile when drawn through 25 cc. of Nessler's reagent, produced a light yellow color, indicating about 0.05 milligram of ammonia. No trace of hydrogen sulphide is given off. Test tubes containing filter paper moistened with basic lead acetate remained perfectly colorless for twenty-four hours in the fermenting heaps, hence it may be safely concluded that no protein decomposition resembling putrefaction takes place.[2] The amount of carbonic acid given off was also much smaller than would naturally be expected from the apparent energy of the action.

Starch.—Small quantities of starch are sometimes found in fermented tobacco when the curing process has not been carried out properly in all parts of the leaf or in parts of leaves broken, or injured by fungi, as observed by Müller-Thurgau, but this occurrence of a small percentage of starch interferes with the flavor just as little as does the closely related cellulose. The well-prepared tobacco wrappers from Florida examined by the writer did not show a trace of starch. The fact, however, that in the curing process the solution of the starch is going on with great energy forms a contrast to the observation that in certain cases remnants of starch remain unattacked during the fermentation process. This admits of hardly any doubt that the diastase[3] is gradually destroyed, perhaps by the proteolytic enzym.

Sugar.—As to the disappearance of the last remnant of sugar during the sweating, amounting, according to Müller-Thurgau, to from 1 to 3.3 per cent, some authors assume oxidation to carbon dioxide and water, and others assume a partial transformation to acetic acid. When it is taken into consideration that an alkaline medium can soon change glucose into organic acids (gluconic, saccharinic, etc.), especially in the presence of air, a more simple explanation would be at hand than

[1] Conn. Agr. Expt. Sta., Ann. Rept. 1892, p. 28. The leaves used for comparison were most carefully selected and were as nearly alike in color, size, and texture as possible.

[2] Nessler's comparison of the sweating process to putrefaction is certainly not admissible; neither is his declaration that the formation of ammonia is not normal, but simply a sign of true putrefaction.

[3] Diastase is absolutely necessary to dissolve and saccharify the starch. The dextrin and maltose thus formed may afterwards be transformed into glucose by the living protoplasm itself, wherever this latter comes under consideration.

V. P. P. 65. Tobacco—7.

U. S. DEPARTMENT OF AGRICULTURE.

Report No. 60.

TEMPERATURE CHANGES IN FERMENTING PILES OF CIGAR-LEAF TOBACCO

BY

MILTON WHITNEY AND THOS. H. MEANS,

OF THE DIVISION OF SOILS,

IN COOPERATION WITH THE DIVISION OF VEGETABLE PHYSIOLOGY AND PATHOLOGY.

LIBRARY OF THE UNIVERSITY OF CALIFORNIA

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1899.

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CURING AND FERMENTATION OF CIGAR LEAF TOBACCO.

INTRODUCTION.

The production of tobacco adapted to the different market demands has become a prominent factor in national economy. Of particular importance is the production of superior cigar leaf tobacco. The filler leaf of a cigar must above all things have a good flavor, good aroma, and good burn. In the wrapper leaf, however, still other qualities come in, such as elasticity, pliability, size, shape, color, size of the veins, the fineness and peculiar grain of the Havana type, and the smooth silkiness of the Sumatra.

Little is known of the chemical properties of the leaf, especially of those which contribute to the flavor and aroma. It is probable that the actual amount of nicotine is relatively unimportant, and it is certain that the excellence of the leaf and its adaptation to market demands is not dependent, except in a very general way, upon the amount of nicotine. It has long been known that certain of the potassium salts, especially potassium chlorid, can not be used at all for the production of high types of cigar tobacco, as they give the leaf a poor burn. It is furthermore an old experience of tobacco growers that excessive nitrogenous manuring tends to produce a large leaf, of inferior quality, containing an increased amount of nicotine. If the prime object of tobacco culture were the production of nicotine, as the prime object in raising sugar beets is the production of sugar, then the rational procedure would be to furnish an excess of nitrogenous manures, but nicotine alone does not make a good cigar tobacco any more than alcohol alone would make a good wine. The substances producing the flavor and aroma, therefore, although probably present in minute quantities, are much more important than the actual percentage of nicotine found in the cured leaf.

Whitney[1] has shown that tobacco suited to our domestic cigars is grown only upon certain soils and under certain climatic conditions. It appears, therefore, that the leaf capable of being converted into a cigar leaf through the ordinary processes of curing and fermentation must

[1] Bull. No. 11, Division of Soils, U. S. Department of Agriculture.

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TEMPERATURE CHANGES IN FERMENTING PILES OF CIGAR-LEAF TOBACCO.

INTRODUCTION.

With the introduction and rapidly extending use of Sumatra tobacco for wrapping our domestic cigars, and with the superior quality and commercial standing of the Cuban tobacco, competition with the products of this country, notwithstanding the tariff on tobacco from foreign countries, has been very severe. Unlike most of our staple farm crops, fashion largely determines the commercial value of tobacco. The mere designation of a tobacco, as Russian, Turkish, or Grecian, carries much weight in the opinion of many smokers and induces them to purchase such tobacco in preference to the domestic grown, simply because it is of foreign origin. Aside from this there are certain qualities about the Sumatra and Cuban tobaccos which are universally recognized as extremely desirable. The duty on wrapper leaf is $1.85 per pound and on filler leaf 35 cents per pound, so no cigar-leaf tobacco is imported into this country without at least 35 cents per pound being added to the original cost. All of the Sumatra tobacco is used for wrapper purposes and is worth on the average from $2.50 to $3 per pound, duty paid. This high price of wrapper leaf, together with the scarcity of Cuban fillers and wrappers during the past two or three years, has greatly stimulated the industry of the production of cigar tobaccos in this country.

The interest in the production of a cigar leaf, and particularly of a wrapper leaf, to compete successfully with the tobacco imported from Cuba and Sumatra, has led to marked developments in the tobacco interests of Florida, Texas, and, more recently, in the Connecticut Valley. The light, sandy soils bordering the Connecticut River produce a wrapper leaf of superior quality which more nearly complies with the present market demands for cigar wrappers than the tobacco from any of the other northern tobacco districts, but still the Connecticut leaf brings only, on the average, about 20 cents per pound for wrapper purposes, while the tariff alone on imported wrappers is $1.85 per pound. The most notable advance in the past few years has been, however, in the development of the cigar-tobacco industry in Florida, where a wrapper leaf of very superior quality is being produced which promises to provide a very satisfactory wrapper for the Cuban tobacco

and to compete successfully with the imported Sumatra, which it resem bles very closely in the most important features. This result has bee attained through very careful and intelligent methods of selectio cultivation, fermentation, and great care in the grading of the lea This experience has extended over a number of years, and the produ every year has been more and more satisfactory.

Great interest has been manifested in these Florida experiments b the growers in the other cigar-tobacco districts, and the Florida met ods have been studied by persons interested in the improvement of t tobacco of other districts.

The investigations of the Division of Soils have shown that the ligh sandy soils of the Connecticut Valley are similar in their physi properties to the tobacco lands of Florida, the Vuelta Abajo Distr of Cuba, and to the tobacco districts of Sumatra. There is, furth more, no such difference in the meteorological data from these pla as would seem to explain the difference in the character of the l produced. It is important, therefore, to carry the investigations furt and to discover, if possible, the causes of the difference between Connecticut leaf and some of the foreign tobaccos with which it co into competition.

It is clearly recognized that the flavor and aroma of the cigar-toba leaf are developed during the fermentation, although the fermenta changes are dependent upon a certain quality of leaf which has b properly cured. The practice of fermentation differs greatly in several tobacco districts, and as the method of fermentation is kn to have a decided effect upon the physical characteristics of the and upon the flavor and aroma, it was considered at least possible the commercial characteristics of the Connecticut leaf might be di the methods of fermentation rather than to the character of the so climate. It was considered advisable to see if the method of fer tation practiced in Cuba, and more recently in Florida, would more desirable commercial characteristics to the Connecticut leaf.

As our investigations have shown no marked difference in the conditions or in the climatic conditions of the growing season, it is sonable to expect that by improved methods of cultivation or o mentation the quality of the Connecticut leaf can be greatly impr If it is found, however, that satisfactory results can not be attain this manner with the soil and climatic conditions, it should be pos to change the specific characteristics of the plant itself through b ing and hybridization, so that under the existing conditions a wra leaf of acknowledged excellence could be produced on these Con cut soils which would compare favorably in the commercial valu pound with the Florida and imported products.

The questions of fermentation and breeding by selection and hy izing of plants belong properly to the Division of Vegetable Physi and Pathology. An arrangement has therefore been made wi

ief of that division to cooperate actively in this work, and many val-
ible suggestions have already been obtained from the investigations
Dr. Oscar Loew, also of that division, which make it appear at least
ssible that the difference in the fermenting power of the Connecticut
af, as compared with the Florida leaf may be modified and the com-
ercial qualities greatly improved in the curing and fermentation of
e leaf. There is reason to believe, therefore, that we will be able in
me to control the fermentation and greatly improve the value of the
onnecticut leaf for cigar purposes.

The present bulletin gives the records of the moisture content and
e temperature of fermenting piles of Florida tobacco as a basis for
e bulk method of fermentation of tobacco in other localities. This is
reparatory to a more extensive line of investigation by Dr. Loew,
operating with the Division of Soils, which it is proposed shall finally
clude a study of the principal tobacco districts of this country.

METHOD OF FERMENTING TOBACCO.

The method of fermenting tobacco as practiced in Florida has been
escribed in Farmers' Bulletin No. 60 of this Department. The tobacco
fermented in large "bulks," the term commonly used in the trade as
pplied to a mass of tobacco piled up for fermentation. It is constantly
atched during the six or eight weeks that the fermentation requires,
) see that the temperature does not go too high and that the moisture
onditions remain favorable.

The methods employed in this fermentation in Florida have been
eveloped as a result of long experience. Even now the proper progress
f the fermentation is only determined as a matter of experience by the
ttendant in charge of the fermenting piles. There are no hard and
ast rules to be given and no really explicit instructions which may be
sed in a new district by a person unacquainted with the methods.

The following description of the Florida method is taken from
'armers' Bulletin No. 60:

> When thoroughly cured and the leaves are in proper case, or order, they are stripped
> ff and tied into hands. These hands are then bulked for the sweat, the Cuban and
> umatra tobaccos being kept separate.
>
> The bulks may be built up directly on the floor, or the leaves may be put into bins.
> n large establishments the temperature and humidity of the room can be thoroughly
> egulated to secure uniform progress of the fermentation. This is done by steam
> ipes to warm the room, in which there are vents for the escape of steam when it is
> esired to make the atmosphere more moist. The temperature of the room is kept
> uite high, and the vapor from the bulk which is being worked over is very pungent
> nd almost overpowering. There is a very strong odor of ammonia, which makes it
> ifficult to breathe.
>
> The bulk is watched very closely, and as the temperature rises it is torn down,
> ach hand of tobacco is taken up and shaken thoroughly to dry it a little, to cool it
> ightly, and to open the leaves so that they will not stick together. Before the
> weat is completed the bulk is pulled down and built up eight or ten times, accord-
> ing to the condition of the tobacco. It is impossible, even for an expert curer, to

the production of a fine quality of leaf, for the dealers, working with large quantities, are able to keep up more uniform conditions and to handle better the different grades, sizes, and colors desired by the manufacturers.

The tobacco when received in the warehouse is roughly graded into wrappers and fillers. All low-grade tobacco and leaf not suitable for wrapping cigars is sweated as filler leaf, although later some wrapper leaves may be sorted out. On the other hand, all of the best grade is sweated as wrappers, although from this also some filler leaves are taken in the final selection.

The present market demands require light-colored wrappers and medium or dark colored fillers. The fermentation always tends to darken the leaf, especially if much water is present in the leaf or if a high temperature develops in the fermenting bulk. Should dark wrappers come into general demand there would be little or no necessity for making the first assortment into wrappers and fillers, as is now done, but all the leaves could be fermented in the same bulk.

In the effort to obtain light-colored wrappers the tendency is to rather undersweat the leaf, leaving it green and bitter. Such tobacco is always cause of complaint on the part of the manufacturer and smoker. If, however, the leaves are thoroughly sweated, the color is apt to be dark, and for that reason undesirable. There is a mistaken impression that light-colored wrappers indicate a mild smoking cigar. To a certain extent this is true, because strong, heavy leaves can never produce a light-colored wrapper; if the light wrappers had been completely fermented they would darken somewhat, but they would lose much of the bitter, harsh taste and unfinished character which is often so objectionable in the light colored cigars. The present effort is to compromise on these lines and produce a wrapper as light as possible, without too great a sacrifice of flavor.

Where the leaf is subjected to a very mild sweat in the bulk to keep the color light, it is well to let it stand some time in the bulk or bale to age. This is especially necessary with filler leaf.

THE MOISTURE CONTENT OF FERMENTING TOBACCO.

The main process of fermentation of Florida tobacco has been already described in the extract from Farmers' Bulletin No. 60; but there were two features which we especially studied as matters of detail, namely, the moisture content of the tobacco and the temperature attained in the fermenting pile.

The tobacco received directly from the curing shed contains always a certain amount of moisture, depending upon the type of tobacco, the quality of the leaf, and the weather conditions to which it has been immediately exposed. Tobacco can only be handled when it is in a moist, pliable condition, and when it comes into this proper "case" or "order" the leaves, after being tied into "hands," are bulked down in the barn until a convenient time for the fermentation.

The dealers attach much importance to the proper conditioning of the tobacco, by natural means where possible, before it is put in the fermenting pile. It is an open question, however, as to whether there is ever enough moisture naturally present in the leaf to complete the fermentation as it should be done. It is nearly always found necessary to add water during the process of fermentation; if so, it must be very carefully done, and should be avoided if possible.

Our investigations showed that the Florida leaf, to be in good case for starting the fermentation, should contain from 23 to 24 per cent of water. Several piles were examined where the water content was about 20 per cent, and in almost every case it was found that tobacco having no more moisture than this was too dry to ferment and even too dry to handle safely. On the other hand, when the tobacco has 26 per cent of water it is too wet and is liable to rot in the fermenting pile. Several cases were noted where this occurred under these conditions.

Dr. Loew's investigations explain why it is necessary to have just the right amount of moisture in the curing and fermentation. He found that the fermentation of the Florida leaf which he examined is not due to bacteria. The claim of Suchsland that the flavor and aroma of finished cigar leaf tobacco is due to the action of certain bacteria is shown by Dr. Loew to be entirely inadmissible. He found no bacteria upon the fermenting Florida leaf except a few spores, which would germinate under favorable conditions. He found, on the contrary, that the fermenting leaf was antiseptic toward putrefaction bacteria, and that a small portion of fresh beef which had been contaminated with bacteria, when wrapped in the fermenting tobacco leaf, kept sweet and fresh for many days after a similar piece of inoculated meat, left exposed to the air, or wrapped in fresh tobacco leaf had become rotten and putrid.

Dr. Loew shows, furthermore, that from the conditions of the fermentation it is impossible to conceive of nutritive matters being supplied from the inside of the cell for the support of bacteria on the outside of the leaf, and he shows also that where an excess of moisture is present, so that this nutritive solution is brought out on to the exterior part of the leaf and conditions favorable to bacterial growth are provided, that the cell walls are broken down and the texture of the leaf is entirely destroyed. It appears, therefore, from his investigations that bacterial fermentation plays no important part in the development of the fine flavor and aroma of the finished leaf.

His investigations show that both the curing and fermentation of tobacco are caused mainly by an oxidizing enzym, or rather by two different enyzyms, one of which, the most active, he calls *oxidase* and the other *peroxidase*. The oxidizing enzyms belong to a class of bodies whose importance in the rôle of plant life and in the physiological changes in plant cells has only recently been recognized. They are related to what were formerly called the soluble ferments, represented

by diastase, which is the active agent in the malt fermentation. A clear conception of the office of these enzyms can possibly be obtained from the somewhat analogous case of purely mineral compounds. Wood oxidizes much more rapidly around a rusty nail than on mere exposure to the weather. The wood actually disappears from around the nail, leaving a hole of considerable size. There is a slow oxidation of wood wherever it is exposed to the weather, as seen in the gradual oxidation and disappearance of boards and logs. In the case of the rusty nail, however, the oxidation is much faster than in the free air; for the wood is able to take up oxygen in the presence of iron oxide much easier than it can take on the free oxygen of the air.

It is supposed that this is the case also with the oxidizing enzyms. They simply act as agents for supplying oxygen to the substance of the leaf, and in this process they may or may not suffer any sort of destruction or impairment in themselves.

To show the extraordinary power and vitality of these agents it may be said that one part of diastase will convert two thousand parts of starch into sugar.

The enzyms are a part of the protoplasm of the plant cell, having a highly complex molecular arrangement, upon which depends the life and activities of the enzym. Of the two oxidizing enzyms found by Dr. Loew in the Florida tobacco the most active, that is the oxidase, is destroyed at a temperature of 152° F. (66° C.). At this temperature the substance is changed into the ordinary form of protein. On the other hand, the peroxidase is destroyed at a temperature of 190° F. (88° C.).

As a rule, the formation of these enzyms is increased when a leaf is slowly starving to death, either through lack of nourishment or through lack of water supply, as when the plant is cut and hung up in the barn. When the plant is hung up for the barn cure, and the leaf dries out very slowly, as it should, the enzyms probably increase in the first stage of starvation, although this has not been definitely determined.

In the early stage of curing the enzyms may push out from the protoplasm in order to collect food material for the starving cell. In this way the enzyms become well distributed in the cell, and are afterwards capable of oxidizing the cell contents in the fermentation pile. On the other hand, if the leaf is quickly killed by sudden drying in a warm, dry wind, the enzyms have no opportunity of developing or of moving out from the protoplasm. They are liable to be entangled in the insoluble protein in this latter case, and afterwards the leaf on being moistened is no longer able to go through the fermentation properly, as the enzyms can not be dissolved. This is the reason why it is necessary to prolong the life of the leaf in the curing shed and allow the curing to proceed gradually. The loss of water must be gradual to insure a slow starvation of the leaf.

The leaf must thus be kept moist for a considerable time after it is

cut and while the curing is slowly progressing to promote these important chemical and physiological changes which are necessary for the proper development of the flavor and aroma during the curing and the after-fermentation period. If the leaf is too moist, however—that is, if there is any water allowed to stand on the leaf, as in very foggy, damp, weather, or in a forced curing where there is insufficient ventilation to carry off the moisture and to prevent condensation on the surface of the leaf, the cell contents may actually be dissolved and brought out on the exterior surface of the leaf and serve in this diluted state as a nutrient solution for the growth of bacteria and various forms of fungi, which may entirely destroy the structure of the leaf. Hence the presence of too much water is the cause of various destructive diseases, such as pole rot, case mold, and the various other troubles which are liable to develop in the curing shed and in the case or bulk fermentation.

The rational mode of preventing these troubles is thus made clearly apparent. The curing must go on slowly, but there must be no actual standing water on the leaf to dissolve out the nutrient substances of the cell and permit of bacterial and fungous development.

We see clearly now, also, the importance of the proper moisture condition of the tobacco in the fermentation pile. The leaf must have sufficient moisture of imbibition to insure the solution of the enzyms, and water should not be allowed to stand for any length of time on the surface of the leaf, nor should there be an excess of water in the leaf which would bring the nutrient matters outside the cell to support bacterial or fungous growth, otherwise the same troubles will occur as in the curing process, and the leaf will be liable to be injured or entirely destroyed.

The significance of the figures given for the moisture content of the Florida tobacco becomes, therefore, very great, namely, that there must be at least 20 per cent of water present in order to bring the enzyms into proper condition, and in order also that the leaf shall be pliable so as not to be injured in the handling. An amount of water equal to about 23 or 24 per cent seems to be the most favorable amount, but 26 per cent was an excess and favored bacterial and fungous changes which injured the leaf to a certain extent.

The heavy filler leaf, which it is intended to put through a hard fermentation, is given all the water it can possibly stand, while the light wrappers are given just as little as will possibly insure a slow fermentation.

If the tobacco when ready to be bulked down is not in proper case, or order, it must be wet artificially in order to bring the water content up to the desired amount. There are several ways of applying this water. With the commoner kinds of tobacco the butts are dipped into a pail of water or of petuning liquid and vigorously shaken in order to draw the water up into the leaves by centrifugal motion. This is the

quickest and cheapest way of wetting the leaf, but it can not be recommended for general use with tobacco of good quality, as it is apt to spot the leaf and rot the stem.

There are various forms of syringes and blow cans with which water, or the petuning fluid, is delivered in a fine spray on the tobacco as the "hands" are vigorously shaken. In some warehouses a room is fitted up for the purpose of getting the tobacco into proper condition. Steam jets and water jets, throwing a very fine spray, are arranged around the room and the tobacco is shaken in these sprays until in the proper condition for bulking. Lastly, steam itself is used as being one of the quickest and best ways of bringing the tobacco into proper condition. Jets of steam are allowed to blow out into the warehouse to keep the air extremely humid and the tobacco is simply turned over occasionally in this moist atmosphere.

Some dealers insist that it is necessary to add water to the leaves in all cases, but this is clearly not necessary in the case of wrappers. Wrapper leaves sweated with the least possible amount of water and the lowest temperature, in which the fermentation is slow and long continued, are in the greatest demand at present by the manufacturers and bring the best prices.

TEMPERATURE CHANGES IN THE FERMENTING FLORIDA TOBACCO.

The bulks are built up for fermentation by laying the tobacco down evenly with the leaves well straightened out and with the butts toward the outside of the pile. Usually headboards are used to keep the pile straight, or the pile may be built against the wall. If the floor is of cement it is well to have raised platforms under each pile, especially where artificial heat is used, in order to secure a free circulation of warm air around the bulk. A layer of heavy paper is usually put upon the floor or upon the platform and the tobacco piled on this. As the fermentation proceeds very slowly on the bottom it is usual to put some previously fermented and moistened leaf immediately at the bottom of the pile. This may be trash and old stuff which has no commercial value. The bulks are of various sizes according to the amount of tobacco and the dimensions of the building, but they usually average about 5 feet wide, 12 feet long, and from 6 to 8 feet high.

It is difficult to ferment properly a small quantity of leaf, and this operation should not be attempted with less than 1,000 pounds of tobacco. In building up the bulk any excessive pressure should be avoided in the first stages of curing, the "hands" are laid on from the outside and simply pressed firmly together. The pile naturally sinks somewhat as it stands, and more tobacco can be put on top within twenty-four hours if it is considered advisable. After the bulk is completed it is well to cover it with blankets or burlaps in order to protect the tobacco from drying out. This is more convenient and neater than

where old tobacco is thrown over the top and sides, as is frequently done.

The temperature of the room should be maintained uniformly at from 70° F. (21° C.) to 80° F. (27° C.) during the active fermentation, and should be dropped to from 60° F. (16° C.) to 70° F. (21° C.) for the so-called "cold fermentation," when the tobacco is simply waiting to be sorted. The relative humidity of the room during the fermentation should be maintained at 80 or 90 per cent, although it may occasionally run up to 100 per cent.

With these conditions maintained in the room and with the proper amount of moisture in the tobacco, namely, about 23 or 24 per cent, the temperature in the middle of the pile should at once begin to rise at the rate of from 8° F. to 10° F. per day. In the case of filler leaf the temperature is allowed to run up to 130° F. (55° C.) or 140° F. (60° C.), which should be attained in from four to six days after the bulk is put up. It seems probable that 140° F. (60° C.) is rather too high and that from 130° F. (55° C.) to 135° F. (57° C.) is the proper maximum to be allowed for ordinary crops. When this temperature is reached, the pile is immediately turned or rebuilt, transferring that which is at the top to the bottom of the new pile. The temperature of the bulk should immediately begin to rise again and should attain about the same or even a higher temperature, but the rate will be slower, so that the second turning will not be necessary for from six to ten days from the time the bulk is turned. The bulk is usually turned from six to eight times before the fermentation is complete, and each time it is turned the leaves are shaken out so that they shall not mat together.

The rate per day at which the temperature rises is determined by the amount of moisture in the tobacco. In some piles examined the temperature rose 14° F., or even 18° F., per day, but this was considered too fast, and the tobacco was found to contain 27 per cent of water. It would have been injured had it not been that the leaf had extraordinarily good body.

The wrapper leaves are put into the bulk in a drier condition; the temperature does not rise quite so rapidly—probably from 6° F. to 8° F. per day—and it is not allowed to go higher than from 110° F. (43° C.) to 120° F. (49° C.). No definite figures can be given for this wrapper fermentation, as we were unable to secure records from a wrapper bulk in the first stages of fermentation. The wrappers are usually fermented first, and when these investigations were undertaken the main part of the wrapper crop at Quincy had already been fermented, and the filler crop was being handled. The wrapper leaf was at that time in bulk, going through what is called the "cold sweat," or the after fermentation, in which the temperature rises slowly and gradually to about 10° F. above the room temperature, and then very gradually cools off, and no further action occurs. The bulk is held in this condition, moder-

ately dry and cool, until it is assorted and graded into different lengths and shades, after which it is immediately baled.

The accompanying table gives the record of the air temperature and the relative humidity in one of the fermenting rooms in which the investigations were carried on. A chart is also given, showing a diagrammatic representation of the same data.

Temperature and relative humidity in the fermenting room.

Date.	Time.	Temperature (degrees F.).	Relative humidity.	Date.	Time.	Temperature (degrees F.).	Relative humidity.
			Per cent.				*Per cent.*
Nov. 26	2 p. m.	70.0	79	Dec. 6	8 a. m.	62.5	87
	4 p. m.	70.5	78		1 p. m.	70.0	.....
27	9 a. m.	50.0	76		6 p. m.	69.5	72
28	8 a. m.	60.0	75	7	6 a. m.	65.0	77
	11 a. m.	63.2	82		12 m.	68.5	.....
	5 p. m.	67.5	100		5 p. m.	68.0	98
29	7 a. m.	71.5	91	8	8 a. m.	66.0	76
	6 p. m.	70.0	95		12 m.	70.0	.....
30	6 a. m.	66.0	75		5 p. m.	70.6	87
	6 p. m.	76.5	78	9	6 a. m.	64.0	93
Dec. 1	6 a. m.	76.0	63		12 m.	63.0	.....
	5 p. m.	81.0	84		5 p. m.	67.7	98
2	6 a. m.	77.5	78	10	8 a. m.	58.5	54
	5 p. m.	83.5	100		4 p. m.	60.0	84
3	6 a. m.	84.0	100	12	7 a. m.	61.0	85
	4 p. m.	83.5	80		12 m.	64.0	.....
4	12 m.	78.0	99		5 p. m.	72.5	79
5	6 a. m.	63.0	98	13	6 a. m.	65.7	77
	12 m.	72.0	.....	14	7 a. m.	58.0	84
	4 p. m.	70.0	81				

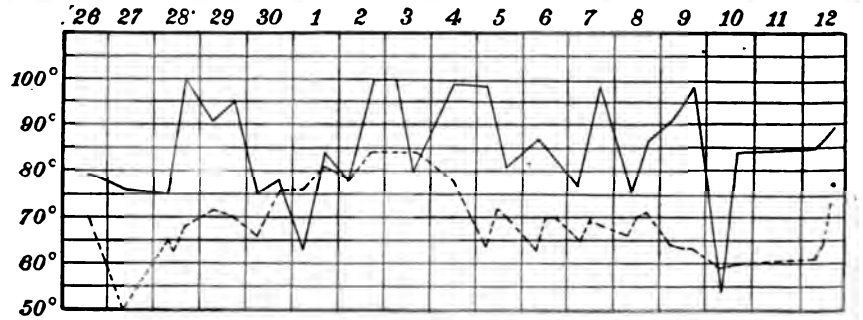

FIG. 1.—Temperature and relative humidity in a packing-house at Quincy, Fla., Nov. 26–Dec. 12. Broken line represents temperature in degrees F. Solid line relative humidity in per cent. Numbers on left stand for both.

Sunday, November 27, was an exceptionally cold day for that locality, and the temperature of the warehouse got down to 50° F. (10° C.). It appears from our observations and from the statements made by the warehousemen that the temperature of the room should range between 70° F. (21° C.) and 80° F. (27° C.) to provide the most favorable conditions for the fermentation. Where the room temperature went much below 70° F. (21° C.) the progress of the fermentation was evidently checked. The temperature and relative humidity of the rooms were taken with a sling psychrometer loaned by the Weather Bureau.

The temperature records of the inside of the tobacco piles were taken with an electrical thermometer, which will be described in a subsequent bulletin of the Division of Soils. With this instrument a small coil of very fine iron wire, properly insulated, is inclosed in a lead pipe, the outer end of which projects beyond the bulk, the coil being well within it. Two wires lead up to the measuring instrument, which is carried from bulk to bulk and attached to the wires each time the temperature observations are to be taken. This gives a very convenient and accurate means of determining the temperature of the inside of the bulk without disturbing the tobacco in any way, as would have to be done in the use of ordinary thermometers. With a single measuring instrument any number of these temperature coils could be observed in different bulks and in different houses not too far apart. One of the best records that was obtained in Florida was from a bulk of mixed wrappers and fillers which was fermented as filler leaf in one of the warehouses in Quincy.

The following table gives the temperature records of this bulk. On December 1 when the coil was put in the temperature was 74° F. (23° C.); on December 7 the temperature was 136° F. (58° C.). This is a rise of about 10° F. per day. The bulk was then turned and the temperature fell to 77° F. (25° C.), and the record was continued until December 14, when the temperature was 125° F. (52° C.) and was still going up. The bulk was not to be disturbed until the temperature had risen to about the same temperature as formerly, or about 135° F. (57° C.), when it was to be turned over again and the fermentation allowed to proceed. During this second period the rise of temperature was about 7° F. per day. In the third period the rise of temperature would have been still slower. These records are illustrated graphically in fig. 2. This fermentation appeared to be normal and satisfactory for the grade of tobacco that was being handled.

Temperature of a fermenting pile of mixed wrappers and fillers of average quality Florida-grown Cuban tobacco.

Date.	Time.	Temperature (degrees F.).	Date.	Time.	Temperature (degrees F.).
Dec. 1	7 a. m.	74.0	Dec. 8	8 a. m.	84.0
2	6 a. m.	88.0		12 m.	87.0
	1 p. m.	89.5		4 p. m.	87.0
	5 p. m.	90.5	9	7 a. m.	92.0
3	7 a. m.	96.0		11 a. m.	94.0
	12 m	98.5		5 p. m.	95.0
	5 p m.	101.0	10	8 a. m.	102.0
5	6 a m.	119.0		12 m.	103.5
	12 m.	121.5		4 p. m.	105.0
	4 p. m.	125.0	12	8 a. m.	116.0
6	8 a. m.	128.5		5 p. m.	118.0
	1 p. m.	132.0	13	6 a. m.	120.0
7	6 a. m.	*a* 136.0		5 p. m.	122.0
	4 p. m.	77.0	14	7 a. m.	125.0

a Bulk torn down and rebuilt.

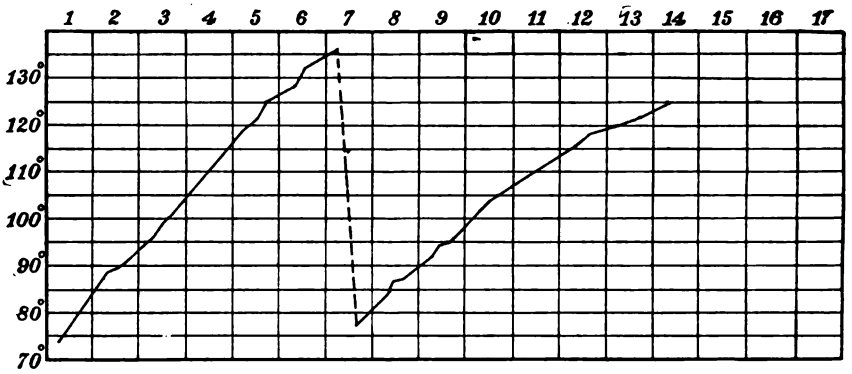

FIG. 2.—First and second rise in temperature in fermenting bulk of mixed wrappers and fillers, Florida-grown Cuban leaf.

The following table gives a record from another pile of the same tobacco in the same warehouse through the first rise in temperature. The temperature on December 7, when the pile was first built up, was 68° F. (20° C.), and on December 14 it was 137° F. (58° C.), when the pile was torn down and rebuilt. The temperature rise here was at the rate of about 9° F. per day. These figures are illustrated in chart 3. December 11 was a very cold day, and the warehouse was not properly provided with heating pipes, the temperature of the room being down to 50° F. (10° C.). It can be seen from the records that this materially checked the progress of the fermentation.

Temperature of fermenting pile of mixed wrappers and fillers of average quality Florida-grown Cuban tobacco.

Date.	Time.	Temperature (degrees F.).	Date.	Time.	Temperature (degrees F.).
Dec. 7	4 p. m.	68.0	Dec. 10	12 m.	94.0
8	8 a. m.	69.0		4 p. m.	98.5
	12 m.	71.5	12	8 a. m.	104.0
	4 p. m.	72.0		12 m.	125.0
9	7 a. m.	75.0		5 p. m.	128.0
	11 a. m.	82.0		6 a. m.	131.0
	5 p. m.	84.0	13	5 p. m.	135.0
10	8 a. m.	91.0	14	7 a. m.	a 137.0

a Bulk turned.

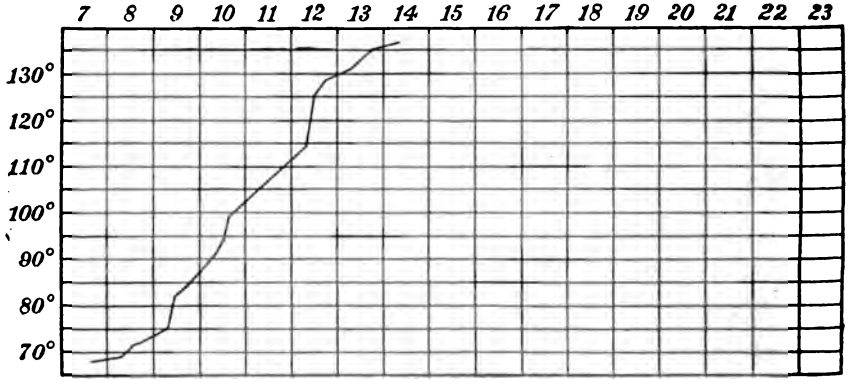

FIG. 3.—First rise in temperature in a fermenting bulk of mixed wrapper and filler, Florida-grown Cuban leaf.

The following record is from a filler bulk which has this history: It had been through the regular process of fermentation, the temperature had risen, and the bulk had been turned over a number of times until it was nearly finished. The fermentation, however, was not quite finished, and yet the tobacco had dried out so far that it could not proceed. The tobacco was therefore moistened and bulked down, and the following temperature records were obtained:

Temperature of last stage of fermentation of filler tobacco after being moistened.

Date.	Time.	Temperature (degrees F.).	Date.	Time.	Temperature (degrees F.).
Nov. 30	3 p. m.	76.0	Dec. 3	4 p. m.	123.0
	6 p. m.	77.5	4	12 m.	126.0
Dec. 1	6 a. m.	85.0	5	6 a. m.	126.0
	1 p. m.	90.0		12 m.	127.0
	5 p. m.	92.5		4 p. m.	127.0
2	6 a. m.	105.0	6	8 a. m.	123.0
	12 m.	110.0		12 m.	121.0
	5 p. m.	115.0		6 p. m.	121.0
3	6 a. m.	121.0	7	6 a. m.	118.0
	12 m.	122.0		12 m.	118.0

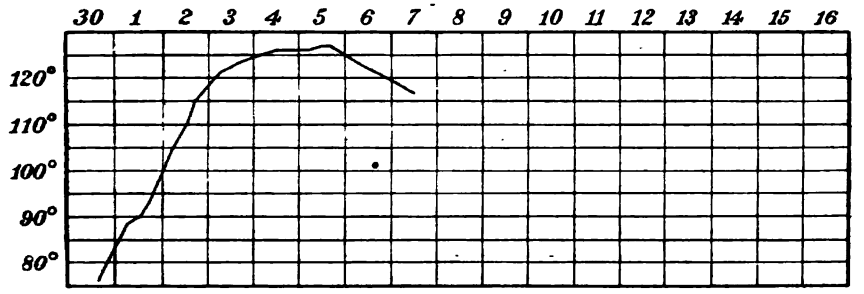

FIG. 4.—Last rise in temperature in filler-bulk. Tobacco had been moistened before bulking.

The temperature on November 30 was 76° F. (25° C.). On December 5 it reached its maximum of 127° F. (53° C.), having risen about 10° F. per day. From this point the temperature began to fall slowly, the fermentation was complete, and from this time the bulk was left undisturbed until it was needed for sorting and packing. This period therefore represents the final sweat, except in this, that the tobacco had been moistened and that the rise of temperature was more rapid in this last period than it would have been had the tobacco not been moistened.

The following record is from a filler bulk that was too wet when it was bulked down, the tobacco containing about 27 per cent of moisture. In two days the temperature rose from 85° F. (30° C.) to 122° F. (50° C.), or at the rate of over 18° F. per day. The cold weather of Sunday, December 4, checked this rapid rise. On Monday the bulk was torn down, the leaves shaken and dried out a little, and repiled. In five days the temperature rose from 90° F. (32° C.) to 145° F. (63° C.), or at the rate of a little over 10° F. per day. The bulk was then turned, when the rise in temperature was much slower, being only about 5° F. per day.

This was the last sweat given this tobacco, as it was finally torn down and sorted on December 16, or two days after our record ceased.

Temperature of fermenting pile of filler tobacco which was too wet to start with.

Date.	Time.	Temperature (degrees F.).	Date.	Time.	Temperature (degrees F.).
Dec. 1	4 p. m.	85.0	Dec. 8	8 a. m.	130.0
2	6 a. m.	109.0		12 m.	135.0
	12 m.	114.5		4 p. m.	136.5
	5 p. m.	118.0	9	6 a. m.	140.0
3	6 a. m.	121.0		12 m.	141.0
	12 m.	122.0		5 p. m.	142.0
5	7 a. m.	a117.0	10	8 a. m.	a145.0
	1 p. m.	90.0		12 m.	81.0
	4 p. m.	95.0	12	7 a. m.	87.0
6	8 a. m.	111.0		12 m.	87.5
	1 p. m.	116.0		5 p. m.	88.0
7	6 a. m.	129.0	13	6 a. m.	92.0
	12 m.	123.0		5 p. m.	97.0
	4 p. m.	125.0	14	7 a. m.	100.0

a Bulk rebuilt.

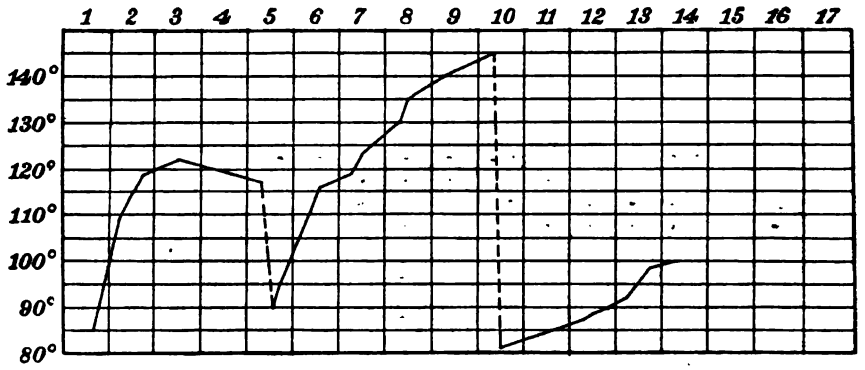

FIG. 5.—Temperature changes in fermenting pile of filler tobacco which contained too much water at the beginning.

The tobacco was a very strong, rather heavy leaf, so that the excess of moisture (27 per cent) and the very rapid rise of temperature at the start, which was checked by cold weather and by turning the bulk, did not injure the leaf, as it would have done if the leaf had been of a finer grade and texture. This record shows the whole operation of the fermentation of this particular lot of tobacco, but it does not represent the most intelligent or the most careful method of fermentation as practiced in Florida.

As already stated, the best grades of wrapper leaf had been carried through the principal fermentation before these investigations had been taken up at Quincy. The best we could do was to secure records from some of the mixed bulks of wrappers and fillers.

Records were, however, obtained of temperature changes in two bulks of a very fine grade of wrapper leaf, which had been carefully fermented and which had just been bulked down as dry as possible to

age in the bulk rather than in the bale. The following table gives the records from these two bulks:

Aging of the finest quality of Florida-grown Sumatra wrappers. Tobacco will be left here until it is sorted.

Date.	Time.	Temperature (degrees F.).	Date.	Time.	Temperature (degrees F.).
Nov. 28	11 a. m.	61.0	Nov. 30	12 m.	66.0
	1 p. m.	63.5		2 p. m.	66.5
	5 p. m.	65.0		6 p. m.	73.0
29	7 a. m.	67.0	Dec. 1	1 p. m.	76.5
	11 a. m.	67.0		5 p. m.	76.5
	6 p. m.	67.5	2	6 a. m.	72.0
30	6 a. m.	67.5		12 m.	72.5
	12 m.	68.0		5 p. m.	72.0
	6 p. m.	69.0	3	6 a. m.	74.5
Dec. 1	1 p. m.	69.0		12 m.	75.0
	5 p. m.	70.0		4 p. m.	75.5
2	6 a. m.	71.0	4	12 m.	78.5
	12 m.	71.0	5	6 a. m.	81.0
	5 p. m.	72.0		12 m.	83.5
3	6 a. m.	74.0		4 p. m.	84.0
	12 m.	74.0	6	8 a. m.	85.0
	4 p. m.	75.0		1 p. m.	85.0
4	12 m.	78.0		6 p. m.	86.5
5	6 a. m.	80.0	7	6 a. m.	86.5
	12 m.	82.0		12 m.	87.0
	4 p. m.	82.0		5 p. m.	86.5
6	8 a. m.	84.0	8	8 a. m.	86.5
	1 p. m.	84.0		12 m.	87.0
	6 p. m.	84.0		5 p. m.	86.0
7	6 a. m.	82.0	9	6 a. m.	85.0
	12 m.	81.5		12 m.	85.0
8	8 a. m.	81.0		5 p. m.	87.0
	12 m.	81.5	10	8 a. m.	84.0
	5 p. m.	81.0		4 p. m.	84.0
9	6 a. m.	80.0	12	7 a. m.	82.5
	12 m.	80.0		12 m.	82.0
	5 p. m.	81.0		5 p. m.	82.0
10	8 a. m.	82.0	13	6 a. m.	81.0
	4 p. m.	81.5	14	7 a. m.	80.0
12	7 a. m.	80.0			
	12 m.	79.0			
	5 p. m.	77.5			
13	6 a. m.	77.0			
14	7 a. m.	77.0			

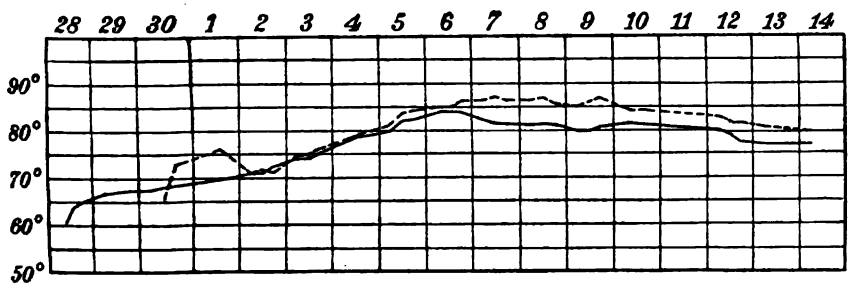

FIG. 6.—Temperature changes in two bulks of finest quality Florida-grown Sumatra wrapper leaf during the aging.

It will be seen that the temperature in these piles rose slowly and very gradually until the middle of the piles was about 10° F. higher than the room temperature, after which the piles seemed to cool off gradually until they attained about the room temperature. At this stage of the operation the tobacco was dry for handling, containing

about 20 per cent of moisture. The tobacco was held in these piles until it was to be sorted and packed, several months perhaps after the bulk had been built up.

When the time came to handle this leaf, in order to bring it into proper "case," it was bulked down with wet fillers and allowed to remain for two or three days, to absorb the moisture and to "draw," as the term is. The rise in temperature was very marked. The stripper leaf was made quite wet, in order that it should impart the needful amount of moisture to the wrappers.

Temperature changes in fermenting piles of Florida-grown Sumatra wrapper, bulked with wet strippers, to bring the leaf in proper case for the sorting table.

Bulk A.			Bulk B.		
Date.	Time.	Temperature (degrees F.).	Date.	Time.	Temperature (degrees F.).
Nov. 28	9 a. m.	56.0	Nov. 26	3 p. m.	84.5
29	7 a. m.	67.0	27	9 a. m.	71.0
	11 a. m.	68.0	28	8 a. m.	87.0
30	7 a. m.	82.5		1 p. m.	95.0
	3 p. m.	92.0	29	7 a. m.	110.0
	6 p. m.	95.5			
Dec. 1	6 a. m.	115.0			

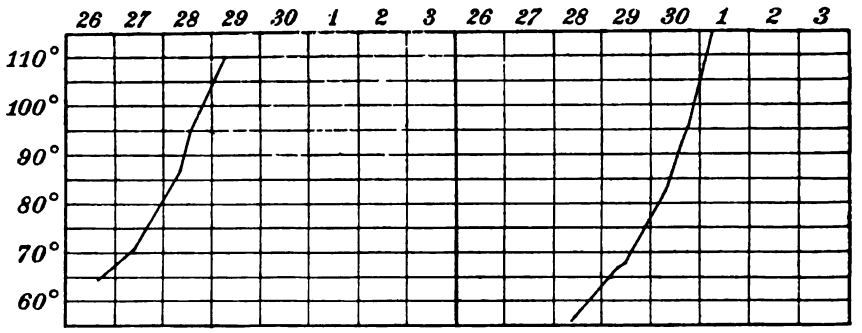

FIG. 7.—Temperature changes in two piles of Florida-grown Sumatra wrapper leaf, bulked with wet strippers, to bring the leaf in case of sorting.

Dr. Loew's investigations showed that in the Florida tobacco which had been carried through the fermentation the oxidase was almost completely used up and the amount of peroxidase was materially diminished; in the filler leaf which had been through the bale sweat and had properly aged and mellowed for two years both the oxidase and peroxidase had disappeared. This is probably a very important and very significant observation, as showing that the full oxidizing power of the leaf had been used up, most of it in the active fermentation and the remainder in the aging or bale sweat.

TEMPERATURE CHANGES IN FERMENTING PILES OF CONNECTICUT TOBACCO.

After securing these records of the moisture content and the temperature changes in the fermenting piles of Florida tobacco, Dr. E. H. Jenkins, of the Connecticut Experiment Station, secured about 1,500 pounds of good wrapper leaf from the Poquonock experiment fields to ferment after the manner practiced in Florida. He had previously bulked down about 1,000 pounds of "seconds," and had reported that the highest temperature attained by the bulk was about 102° F. (39° C.). With the information in regard to the Florida conditions, however, we attempted to force the sweat of the "seconds" by wetting up the tobacco in the way practiced in Florida. The "seconds" had dried out somewhat in the previous fermentation and the leaves were moistened with fine spray and shaken out well, and when they were bulked down they contained about 27 per cent of water, which was above the average water content of the Florida leaf. The wrappers had about the same amount of water without any artificial wetting and were in high case for fermentation, according to the Florida standards.

A basement room was fixed up with steam pipes and provision made for the escape of steam into the room. It was found quite possible, even in the coldest weather, to maintain a temperature of at least 80° F. (27° C.) and a relative humidity of at least 80 per cent. For nearly three weeks the maximum temperature of the room varied between 79° F. (26° C.) and 92° F. (33° C.), and the minimum temperature between 76° F. (25° C.) and 88° F. (33° C.). The relative humidity varied between 72 per cent and 100 per cent, and was on the average about 80 per cent. The room conditions were therefore maintained according to the Florida standards.

The tobacco was put into two good-sized bulks, the 1,500 pounds of wrappers in one bulk and the 1,000 pounds of "seconds" in the other. Some old tobacco was put at the bottom of each bulk and the bulks were covered with blankets, which were kept moist. The wrapper leaves were bulked down on January 13, and the temperature of the middle of the pile was 65° F. (18° C.). On January 18 the bulk had a temperature of 91° F. (33° C.), indicating a rise of about 5° F. per day, and as the room temperature on the 18th was on the average about 87° F. (31° C.) and had been held so for four days, the temperature of the pile was hardly more than 4° F. above the temperature of the room. As the temperature of the bulk was going up so slowly the bulk was torn down and rebuilt. This was done partly to examine the tobacco and see what condition it was in, and partly to see if the exposure to the air in handling the tobacco would excite a more rapid fermentation. By January 22 the temperature of the pile was 99° F. (32° C.), about 11° F. higher than the mean temperature of the room. The average rise of temperature for the four days was but 3° F. per day. The temperature remained constant thereafter, and in fact dropped to 97° F.

(36° C.), when on January 27 the bulk was again torn down in order to see what the effect would be. The temperature again rose very gradually, until on February 3 it was 90° F. (32° C.), or about 8° F. higher than the mean temperature of the room. The rise in temperature for this third period of the fermentation was about 1° F. per day.

The work with the pile of "seconds" gave the same results. The temperature rose at the rate of about 4° F. per day until a temperature of 100° F. (38° C.) was attained, after which it gradually fell, and on February 3 the temperature of the pile was 85° F. (29° C.), while the mean temperature of the room was 81° F. (27° C.).

These results, which will be reported in more detail by Dr. Jenkins, were surprising and somewhat disappointing. It was evidently clearly impossible to force the fermentation of this tobacco, as was done in the Florida leaf. Under exactly the same conditions the Florida tobacco would have increased in temperature at the rate of about 10° F. per day up to at least 130° F. (55° C.), when it would have been necessary to turn over the pile in order to check the fermentation. The temperature of the Connecticut tobacco could not be forced up beyond 100° F. (38° C.) or 102° F. (39° C.), when it would gradually subside. After opening up the pile and allowing the leaves to come into contact with the air it would heat up again more slowly than before and to a lower maximum temperature.

The process of fermentation seemed to be normal so far as it went. There was the same evolution of ammonia as in the Florida leaf and much pungent matter characteristic of the Connecticut seed leaf was thrown off, but it did not seem as though the oxidizing power of the leaf was sufficient to drive off all of this class of substances which it is desirable to expel from the Connecticut leaf in order to get rid of the peculiar "seed flavor," which is so marked a feature of the Connecticut tobacco.

The whole matter was then referred to Dr. Loew. It will be remembered that Dr. Loew found in the Florida leaf that there were two kinds of oxidizing enzyms. The most active of these he called the oxidase. This is an exceedingly active oxidizing agent but it is easily destroyed, that is, converted into ordinary protein. It is destroyed at a temperature of about 152° F. (66° C.), or by traces of various substances which do not affect, or only very slightly affect, the peroxidase, which is decidedly weaker in its oxidizing power but which is much more stable. In the Florida leaf both of these were present in abundance in the cured leaf as it comes from the barn. They both disappear to a marked degree on sweating, and finally they are not found at all in the leaf that has been through the bale sweat and has aged for a couple of years.

The barn-cured leaf from Connecticut contained none of the oxidase; that is, the most active ferment. It did, however, contain a considerable amount of peroxidase. In the "seconds," which had been once

fermented and afterwards moistened and resweated, there was none of the oxidase and only a trace of the peroxidase, so that this oxidizing agent was evidently used up in the course of the fermentation. Finally, in a sample of wrapper from the crop of 1897, which had been fermented by the usual process of the "case sweat," there was none of the oxidase and only a faint trace, practically none at all, of the peroxidase. So it seems as though the peroxidase was completely destroyed when the fermentation has been completed and the tobacco has properly aged.

This discovery unquestionably shows the reason why it was impossible to force the fermentation of the Connecticut leaf by the same methods and under the same conditions as practiced in Florida.

It was important to explain this phenomenal difference between the Connecticut and Florida leaf. Fortunately Dr. Jenkins had taken up a tobacco root during the previous summer, potted it, and kept it in the greenhouse for some investigations of his own. This plant was turned over to Dr. Loew, and he found quantities of the oxidase in the leaves and stalk. Evidently, therefore, the green Connecticut plant has the same oxidizing enzyms present as the Florida plant, but in some way between the time the plant is cut in the field and the time it comes out of the curing shed the active ferment, the oxidase, is lost. It may be owing to the period at which the tobacco is cut, the conditions in the curing shed, or some deleterious substance present in the leaf or formed in the slow starvation of the leaf during the curing process. The thing to do, evidently, is for Dr. Loew to carry out his present plans and study the Connecticut crop in the field and watch it through its various stages of growth, curing, and fermentation, in order to see where this oxidizing enzym is lost and to suggest changes in the method of cultivation, harvesting, or curing which will tend to preserve it for the proper fermentation of the leaf. Very important modifications of the existing methods of cultivation and fermenting the Connecticut tobacco appear to depend upon the results of this scientific investigation.

THE TEST FOR THE OXIDIZING ENZYMS.

The tests for the oxidizing enzyms of tobacco are so simple, and the fact of their presence or absence is so important and so interesting that the methods used by Dr. Loew are described here for the benefit of anyone who desires to make the test.

The reagents used are guaiac resin, ordinary alcohol, and peroxide of hydrogen. These can be ordered of any druggist. One gram of the guaiac resin, or a piece about as large as a bean, is dissolved in about an ounce and a half of alcohol. This solution does not keep well. The guaiac resin itself will keep for any length of time when undissolved in the alcohol.

To test for the oxidase, take a piece of tobacco leaf, dry it at not over 120° F., and pulverize it very finely. Then mix it thoroughly with about

15 times its weight of cold water, mashing the leaves so as to extract thoroughly with the water. This should stand for about one hour for the extraction of the oxidase. After standing for this length of time the solution should be filtered either through a piece of filter paper, blotting paper, or very fine linen. The residue remaining on the filter should be pressed so as to express as much of the juice as possible. Half of this tobacco extract should be put into a small glass, such as a test tube or a wineglass, and five or ten drops of the alcoholic solution of guaiac resin should be poured in and thoroughly stirred. If the oxidase is present an intense blue color will appear within a few minutes; if it is not present no change in color will occur. If the solution turns blue only after ten minutes no attention should be paid to it, as it may happen even if no oxidase is present. If at the end of fifteen minutes the solution has not turned blue, pour in a few drops of peroxide of hydrogen; if there is any of the peroxidase present an intense blue color will immediately appear.

If the guaiac tincture gives a blue color within a short time without the addition of peroxide of hydrogen, thus indicating the presence of oxidase, the second portion of the tobacco extract should be heated in hot water until it has attained a temperature of about 158° F. (70° C.) for a minute or two. This will destroy the oxidase. The temperature must not go up to 188° F. (87° C.), because this would destroy the peroxidase also. After the solution has been heated to 58° F., to destroy the oxidase if present, add, after cooling, five or ten drops of the guaiac tincture and then a few drops of commercial peroxide of hydrogen, when an intense blue color will indicate the presence of peroxidase in the sample of tobacco.

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U. S. DEPARTMENT OF AGRICULTURE.

Reports

Report No. 61.

TEA CULTURE:

THE EXPERIMENT IN SOUTH CAROLINA.

BY

DR. CHARLES U. SHEPARD,
SPECIAL AGENT IN CHARGE TEA CULTURE INVESTIGATIONS.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1899.

SOUTH FRASER TEA GARDEN, FOUR YEARS OLD, PLANTED WITH DRAGON'S POOL (CHINESE) TEA SEED.

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LETTER OF TRANSMITTAL.

PINEHURST PLANTATION,
Summerville, S. C., September 15, 1899.

SIR: I have the honor to transmit herewith, in accordance with your request, a report on tea growing at this place, and to suggest that the facts be made public as the means of encouraging others to take part in the development of this industry.

Respectfully,

CHARLES U. SHEPARD,
Special Agent in Charge Tea Culture Investigations.

Hon. JAMES WILSON,
Secretary of Agriculture.

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TEA CULTURE: THE EXPERIMENT IN SOUTH CAROLINA.[1]

INTRODUCTION.

The problem of raising tea in the southern part of the United States has been discussed for many years. As early as 1848 Dr. Junius Smith made a successful planting at Greenville, S. C., but the work was not continued and interest in tea culture abated. In 1881 Congress made an appropriation for an experiment in tea culture, but when Mr. William Saunders, Horticulturist and Superintendent of Gardens and Grounds of the Department of Agriculture, made an examination of the work done under it he found that owing to the illness of the expert, Mr. John Jackson, and other causes the money had been injudiciously expended and reported that there was little prospect of anything of value being accomplished. Thereupon by recommendation of Hon. George B. Loring, Commissioner of Agriculture, the experiment was closed.

In 1892 the subject was taken up again in the Annual Report in a report by the writer upon the operations on the Pinehurst estate at Summerville, S. C. In 1897 a second report upon the work there was made by Mr. Saunders. The statement now published continues the presentation of the results obtained on the Pinehurst plantation.

It seems probable from the facts so far gathered that the cultivation of tea can be made profitable in the warmer portions of the United States in two ways. One is by establishing a plantation on the scale of the experiment at Summerville, with capital sufficient to carry the work to a point where the product can be offered on equal terms with teas holding an established place in the markets of the United States. The other is to grow tea for home use in the farm garden. In either case tea growing can be undertaken safely only where the temperature rarely goes lower than 25° F. and never below zero, and where a liberal supply of water can be depended upon. There is probably no place in the United States where the rainfall is sufficient for the best results with the tea plant, and irrigation should where possible be provided for in growing tea.

The experimentation at Summerville, on the growth and manufacture of tea, began about ten years ago. At the commencement it was wisely on a small scale, but has been gradually increased until now over 50

[1] This paper brings up to date the reports on the growing of tea by Dr. Charles U. Shepard at his farm "Pinehurst," Summerville, S. C. Previous statements of the progress made will be found in the Annual Report of this Department for 1892, and in Circular No. 1, Division of Gardens and Grounds, this Department.

acres have been planted in tea. When the plants arrive at full bearing, the yield should be at least 10,000 pounds of high-grade tea; and this should suffice for the object in view, viz, to determine whether commercial tea may be profitably grown under the local conditions of soil, climate, and labor.

It was desirable to conduct the experiments with as many varieties of seed and under as different conditions of soil and location as possible. To this end, by the kind assistance of the Department of Agriculture and by purchase from foreign and domestic producers, a considerable variety of seed, representing many of the choicest sorts of tea, was obtained. Gardens were established on flat and on rolling land, in drained swamps and ponds, and on sandy, clayey, loamy, and rich bottom soils.

The problem of providing labor for plucking tea leaf has been solved so far as a steady and skillful band of nimble-fingered children goes; but its price is inordinately high as compared with the Orient. It was indispensable to secure a reliable corps of pickers. To meet this condition there was built a comfortable schoolhouse and a competent teacher engaged. (Pl. VII, fig. 2.) The colored families of the neighborhood were then invited to send their children to the school free of charge. They would be taught the ordinary branches, and also would be taught to pick tea, and so earn money to buy food and clothing. The offer was accepted, and now there is a good list of pupils to draw from as pickers are required.

It was from the outset expected that many of these attempts would prove either partially or wholly unsuccessful. But being thoroughly convinced of the value of all experimental work honestly carried out and faithfully reported, the writer has not regretted the labor and expense incurred in these operations, especially as all but one (an attempt to introduce teas of too tender growth) have given at least some return and are steadily growing in yield.

GOOD SHOWING OF DRAGON'S POOL TEA.

The South Fraser tea garden makes a remarkable showing. It contains slightly more than 2 acres of tea bushes, planted at 4 by 4 feet distances. The bushes were raised from seed procured in 1892 through the kindness of the United States Agricultural and State Departments and John Fowler, esq., United States consul at Ningpo, China. It came from a celebrated garden near Hangchow, the capital of the Province of Chekiang, called Loong Tsin, meaning Dragon's Pool. Mr. Fowler wrote that the seed was of the "very best" sort and that the leaf was always made into green tea. Concerning the tea he also stated: "It has no market name, for the reason that it is not sold outside of the place of growth. It can not be bought in this port (Ningpo) nor at Shanghai. It is sun dried, and of course is not colored artificially. It is not exported; it is too dear. It costs 10 cents per ounce—$1.60 per pound—at Hangchow. Only Chinese can afford to use it; it is too dear for Americans—i. e., those in America."

As shown in the frontispiece, this garden is remarkably thrifty. The vacancies amount to about 4 per cent only, and visitors practically acquainted with Oriental gardens have expressed themselves as surprised by its luxuriant and uniform growth, even to the extent of stating that it equaled anything they had seen in the East. The bushes are thick, of comparatively low growth, and globular form. The leaf is generally rather small and quite tender; it is well adapted for the manufacture of either green or black tea, although the weight of opinion among tea experts is that the latter product is the better of the two. The garden is mostly situated on a knoll, but a portion extends down into low moist land. The ground is clay loam, with a stiff clay subsoil. It has been heavily enriched every spring with a high-grade fertilizer at the rate recently of 600 pounds to the acre. It suffered comparatively little from the February freeze, only small patches requiring pruning back to within a few inches of the ground.

The yield of (dry) tea has been as follows:

	Pounds.
1894	83.8
1895	185.7
1896	215.9
1897	247.5
1898	307.3
1899 to September 15	469.1

There is every prospect that the crop of this year will exceed 500 pounds by the end of the season. It is safe to add that there are few gardens in China which yield a crop of over 200 pounds (dry) tea to the acre. It remains to be seen to what extent the output of this garden may grow.

SUCCESS OF THE ROSE TEA GARDEN.

The constant purpose and hope were to find from all of the data obtained some one way, readily accessible to all, by the employment of one or more sorts of seed and under conditions readily communicable to others, whereby tea may be profitably grown and manufactured in this section. This result seemed to have been demonstrated when the following report of the Rose tea garden was published last fall in the News and Courier, Charleston, S. C., September 15, 1898:

> The site [of the "Rose Garden"] was an old piney woods pond, with a black, rich (in humus) but sour surface soil, overlying quicksand and, yet lower, clay. The ground was thoroughly subsoil drained, heavily sweetened with burnt marl and deeply plowed. About 1,000 plants of acclimated Assam-hybrid tea were set out at 6 by 6 feet, "quincunx." Whether from the slowness experienced in overcoming the original acidity of the soil or from the comparatively feeble growth of the seedlings during the first few years—in this respect resembling its relative, the camellia japonica—little progress was made from 1890, the date of the establishment of the garden, until 1894, although some leaf was plucked from it in 1892.
>
> Again, the system of pruning practiced at the start of the experimentation, whereby clean stems were maintained, had to be abandoned after the loss of many plants and a degree of disappointment which almost caused the cessation of further work in this direction.

At present the garden contains about 800 vigorous bushes, each one composed many stems, the result of cutting out the original main stem and inducing a luxuriant sucker growth. There are also about 200 younger plants occupying the place where older ones died; they naturally produce less leaf. Altogether, this garden less than an acre may be fairly regarded as containing the equivalent of 900 plants in good bearing.

INCREASE OF PRODUCT.

The output of green leaf from it has been as follows: Crop of 1892, 56 pounds crop of 1893, 81 pounds; crop of 1894, 151 pounds; crop of 1895, 333 pounds; crop of 1896, 600 pounds; crop of 1897, 648 pounds; crop of 1898, 1,000 pounds to September 1, with the prospect of reaching almost 1,200 pounds by the end of the season.

It is to be noted that there has been a material increase each year over the preceding, amounting to almost if not quite 100 per cent, with the exception of 1897, when a prolonged autumnal drought materially interfered with the leaf production. It is, of course, impossible to fortell to what limits this expansion may extend before reaching that slight annual variation which marks the maturity of the plant. But it would not be surprising if the outturn were doubled within a year or two. Twelve hundred and sixty pounds of green leaf will afford 300 pounds of standard Pinehurst black tea.

On a basis of 800 plants in the "Rose Garden," the production per bush is 5 ounces of tea. If it were a full acre the yield would approximate 400 pounds. And if the plants had been placed at shorter distances apart, as is the practice in the Orient and now at Pinehurst, the output per acre should be materially larger. The average yearly production per bush in Japan does not exceed 1 ounce; in China it is from 1 to 2 ounces; in India and Ceylon 3 to 5 ounces. In the last-named country there are estates which annually produce over 1,000 pounds of tea to the acre; but they constitute the rare exceptions. Oriental tea gardens usually contain about 2,000 plants to the acre.

This gratifying productiveness of an experimental garden of almost an acre affords good ground for the belief that commercial tea may be grown in South Carolina in quantity quite comparable with the average yield of the most favorably situated Oriental countries. But the "Rose Garden" is not to be regarded as an exceptional result, nor of difficult imitation. Two larger gardens, also formerly piney-woods ponds, planted with Darjeeling seedlings, promise successful rivalry within a few years, and yet others appear to be awakening to a more vigorous productiveness.

COST OF PRODUCTION.

The cost of a crop of 300 pounds of tea from the "Rose Garden," by reason of greater productiveness, is much less than that from Pinehurst as a whole, and yet it is evident that very material reductions might be secured were its area even one-tenfold enlarged; much more so did it contain 100 acres. The following table shows the actual cost of the several operations in the growth, picking, and curing of the crop of 1898 in the "Rose Garden," as also the estimated and materially reduced expense for the same rate of production on a larger scale:

Items of cost.	Actual cost per pound.	Possible reduced cost per pound.
	Cents.	*Cents.*
Pruning	3	2
Manuring	3	2
Cultivation	1½	1
Leaf picking	14	8
Factory work	6	3
Total	27½	16

A glance at the above table shows that the chief expense is that of gathering the af. Experience has demonstrated that a smart lad or grown girl can pick from a ood "flush" 20 pounds of green leaf in ten hours, or, say, enough to make 5 pounds f tea. This should be done for 30 cents, or at 6 cents per pound. The supervision i the field will add 1 cent. With immature plants or poor "flushes" there is necsarily much more labor to be spent, and consequently more time in securing the me amount of leaf. Again, the "fineness" of the plucking materially influences s cost. The picking of a coarser and larger leaf or two from each shoot greatly ncreases the yield and lessens the cost. But with medium leaf picking, and in outhern localities, where labor is cheap, with an outturn of at least 400 pounds of a to the acre, this expense should not exceed 8 cents per pound.

There remains to be considered the cost of superintendence and the fixed charges r the outlay in the establishment of the garden and its maintenance until self-upporting. As to the former, the cost will largely depend on the size of the crop; n a production of 100,000 pounds per annum it should not exceed 2 cents per pound f tea. The expense of putting the land in suitable condition for a tea garden hould not exceed that for any other intensive crop. The cost of raising and setting ut the tea seedlings will vary from $25 to $50 per acre, according to whether raised om domestic or foreign seeds. In the establishment of a large tea estate the initial xpenses are necessarily heavy, but it should be borne in mind that once well done i is practically for all time. The best Japanese tea is said to be gathered from ushes two hundred years old.

QUALITY OF THE TEA.

The leaf plucked from the "Rose Garden," as indeed from the whole estate, is ne, i. e., it very rarely consists of more than the Pekoe tip and two leaves, and hen only to the first Souchong. Heretofore, and without the aid of a protective uty it has been possible to sell all of the Pinehurst (black) tea at $1 per pound retail. t remains to be seen whether the duty will be repealed now that hostilities have eased, or, if not, what effect it will have on the price of the better grades of tea. But after all deductions—and they are not to be underrated—it must be realized that here is a wide margin of profit between the cost of 1 pound of "Rose Garden" ea if produced on a large scale, say 25 cents, and the wholesale price of an equally ood imported tea, say 50 cents. A profit of 10 cents per pound means a profit of 40 per acre on an annual production of 400 pounds of tea, and higher profits per ound, with increasing yield per acre, will rapidly swell the income.

It is now to be added that without undue endeavor the writer sold his crop of 1898, about 3,000 pounds, as also about 500 pounds of the crop of the previous year (which had been repurchased to maintain prices), altogether about 3,500 pounds, at a profit of about 25 per cent. But this simple statement fails to convey an adequate conception of the achievement. The Pinehurst black tea has a distinctly characteristic flavor, and, like some of the choicer Oriental teas, its liquor has more strength than its color indicates. These qualities render its introduction slow. But it has always proved a difficult matter to change the taste of tea consumers; notably so in the introduction of Ceylon tea into Great Britain, the mother country of its producers. Nevertheless there has been a steadily increasing demand for Pinehurst tea, and a great many people will drink no other.

SEVERE TEST OF TEA GARDEN BY COLD WEATHER.

The past winter has fortunately (for the sake of most conclusively testing the feasibility of the local cultivation of tea) subjected the

gardens to an extraordinary ordeal, viz, the greatest cold in one hundred and fifty years—the fall of the thermometer on the morning of February 14 to half a degree below zero, F. Happily this occurred when the ground was covered to the depth of 5 inches with snow. It was observed that those plants which were in the most exposed situations suffered the least, having been brought by the previous cold weather into a state of hibernation which enabled them to withstand the extreme cold, whereas those which were in sheltered positions or in the most luxuriant growth suffered greatly in all parts above the snow level. The result was, that it was found necessary to rigorously prune back to within a few inches of the ground all of the bushes in the most productive gardens, which are generally in the drained ponds, and elsewhere those individual plants which especially suffered from the cold. The accompanying illustrations (Pls. I–IV) are from photographs of two fields, taken last autumn and in April of this year, and exhibit the extreme luxuriance of their leaf production at the former time and the enforced severity of the pruning at the latter. On May 1 every clump of shorn roots—for our present system of cultivation aims to substitute a cluster of straight vigorous stems for the single clean trunk—was more or less covered with a thrifty outburst of young vegetation. This gave promise that the phenomenal freeze of 1899 would have no further ill effect than that which follows the customary low pruning every five or more years in India and Ceylon, which necessarily reduces production during the following few months, or, perhaps, entire season. Plate V, made from a photograph taken of the Rose tea garden in July of the present year, shows that our expectations have been more than realized, as the plants are fully two-thirds as large as they were at the same time last year.

The anticipation that the phenomenal cold of last winter would not materially diminish the tea crop of 1899 is being substantiated. A comparison of the yield of dry tea for the two seasons shows the effect of the previous severe winter in the diminished production of leaf in the early part of the plucking season, as also a gradually increasing yield thereafter until by the end of August the total crop exceeded that of the previous season by about 23 per cent.

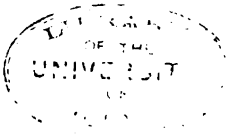
Tea crop, seasons of 1898 and 1899.

For the months of—	1898.	1899.
	Pounds.	*Pounds.*
April	74.6	None.
May	472.9	445.1
June	428.2	581.2
July	671.7	868.3
August	623.8	900.5
	2,271.2	2,795.1

The percentage of (apparently) seriously injured plants is small; that of killed outright yet less. At present the outlook for 1899 is

LINCOLN TEA GARDEN, AUTUMN, 1898, WHEN FOUR YEARS OLD.

Planted with Darjeeling tea seed.



LINCOLN TEA GARDEN, APRIL, 1899, SHOWING EFFECT OF VIGOROUS PRUNING AFTER SEVERE COLD OF FEB...

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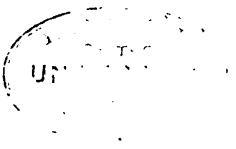
ROSE TEA GARDEN, AUTUMN OF 1898, PLANTED WITH ASSAM-HYBRID TEA SEED.



ROSE TEA GARDEN, APRIL, 1899, SHOWING EFFECT OF VIGOROUS PRUNING AFTER SEVERE COLD OF FEBRUARY.

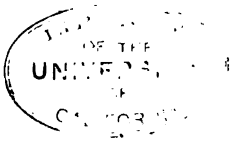


FIG 1.—ROASTING AND ROLLING GREEN TEA.

FIG. 2.—A TEA NURSERY IN JULY.

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or a crop of over 3,000 pounds. The Rose and Lincoln tea gardens, which after the February freeze were pruned almost to the ground, have sufficiently recovered to afford small pluckings, judiciously made, with the promise of abundant later flushes. The bushes in the Rose garden might be better termed "clumps," so luxuriant is the outburst of shoots. They average almost 30 inches in height and 36 inches in diameter, and at a recent plucking (August 18) afforded 22 pounds of dry) tea. There has not appeared any diminution in the strength of the finished tea.

CURING AND QUALITY OF GREEN TEA.

Considerable green tea has been made this season and it has found a fair sale. Designed to imitate the better class of teas made in the Orient and practically unknown here, it was not expected to find a ready market at the comparatively high price necessitated by its having to be manufactured wholly by hand. Plate VI, figure 1, shows the two processes of roasting the fresh leaf in an iron pot with a very thick bottom and hand rolling on a table, which are the main points in the manufacture of green tea. As yet no mechanical substitute for these combined operations has been invented. The rolled and partially dried leaf is afterwards fully dried under constant stirring and at a decreasing temperature. Thus far the mechanical apparatus erected at Pinehurst for making green tea in vacuo has failed to produce the desired results, but it is hoped that later experiments may demonstrate some advantage from this process.

Young and tender leaf from several sorts of tea plants was used in the manufacture of green tea. The best results have been obtained from Formosa leaf, but Japanese, some Chinese (notably that obtained from the celebrated "Dragon's Pool" tea estate), and Kangra varieties have yielded satisfactorily. The bushes of these sorts are smaller and the yield less than is the case with the Ceylon and Indian. The leaf is also smaller and thicker and apparently less quick to oxidize, consequently better adapted for the manufacture of green tea.

The green color of the infusion of Pinehurst green tea has attracted keen interest in the trade and among consumers. Oriental teas can hardly furnish the like in this country. The length of the transportation induces a change of color in their liquor from greenish to yellowish red. It is well to urge upon most tea drinkers that the raspiness, which many conceive to be the strength and value of a tea, is chiefly due to tannic acid and similar substances, which are deleterious rather than nerve strengthening. A tea may be rich in this last property, and yet neither exhibit much color nor provoke throat irritation nor act injuriously upon the stomach.

BUILDINGS AND MACHINERY.

A well-equipped two-story factory with a daily capacity of 50 pounds of dry, black tea has been built. It has over 2,000 square feet now

available for withering the leaf, with the possibility of almost doubling that surface. A tea-rolling machine which does work equal to that done by 15 or 20 men at hand rolling, and two hot-air drying machines fully adequate for all the needs of the place, form part of the equipment. There is also the beginning of a green-tea factory with specially designed machinery for rolling and drying leaf in vacuo, i. e., in a chamber from which the air has been pumped in order to prevent oxidization. Plates VII and VIII show several steps in the manufacture of black tea. In the farther room to the right in figure 1 of Plate VII may be seen men laden with Swiss trout baskets, which they have borne to the factory from the tea gardens where the children have filled them with tea leaf. This is not allowed to remain any great length of time in the gardens

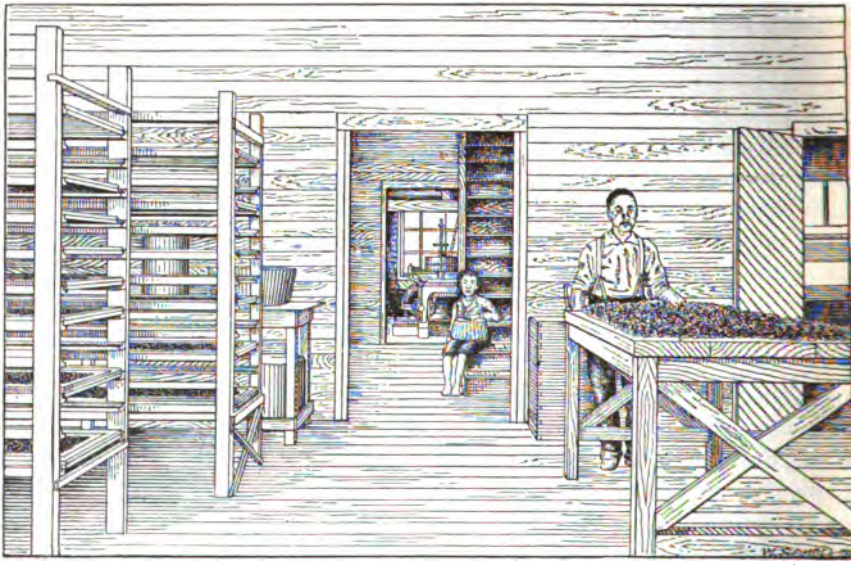

FIG. 1.—Rolling room of tea factory; "Little Giant" tea rolling machine in farthest room; in for ground, right side, roll being broken up; left side, broken roll spread on trays and exposed in frame for oxidation.

for fear lest fermentation may ensue. When brought to the factory i is carefully inspected and weighed.

It is taken upstairs to the withering lofts shown in the illustration c the upper story (Pl. VIII). Every pound of made (black) tea represent over 40 square feet of withering space. The usual output of the factor in the busy season is about 50 pounds of dry tea per diem. There need therefore for a great deal of floor room. This is supplemented b traveling trays of cloth, shown in the illustration. They are loaded o the floor; hoisted to top of room; transferred to the running gear, b which means they may be exposed to the hot air ascending throug the pit from the tea driers below, or shoved where it is cooler. The

FIG. 1.—LOWER STORY OF TEA FACTORY.

FIG. 2.—SCHOOL FOR TEA PICKERS.

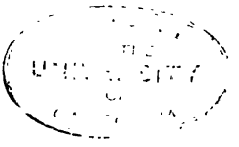

FIG. 1 – UPPER STORY OF TEA FACTORY.

FIG. 2.—LOFTS FOR WITHERING TEA LEAF.

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may be dumped where convenient when the tea has been sufficiently withered.

The tea leaf is then taken to the rolling room on the lower story (fig. 1), where it is rolled by machinery. A "Little Giant" rolling machine (fig. 2) is shown in the farther room of the lower story. After being rolled, the "roll" is brought into the room shown in the fore-

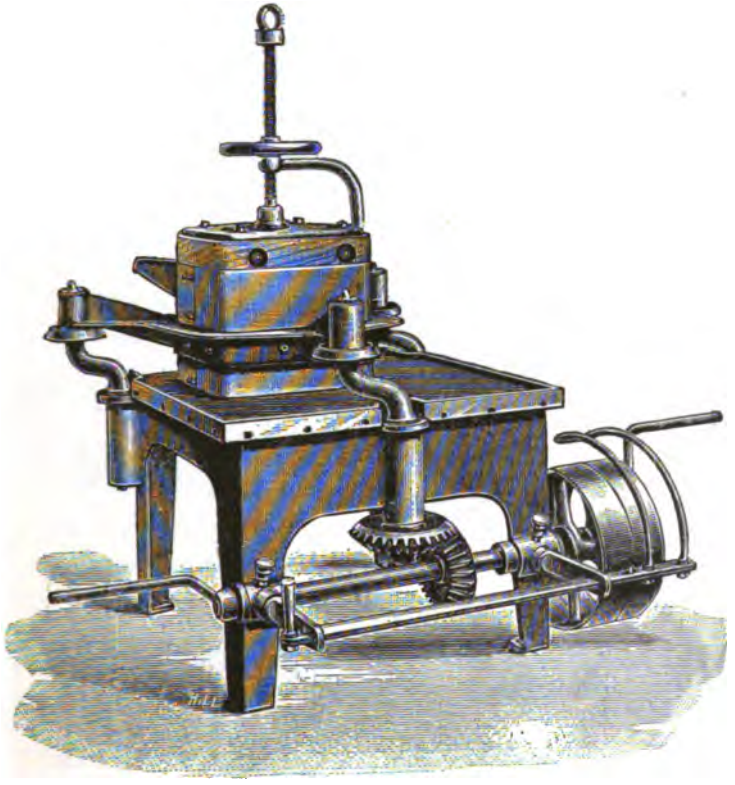


FIG. 2.—"Little Giant" tea rolling machine.

ground of the illustration of the lower story; it is broken up, bad leaf removed, and then spread on clean cloths on trays, which are exposed for oxidation to the action of the air in the frames shown on the left. When sufficiently oxidized, the leaf is "fired" in driers which are located in the middle room (fig. 3). The finished tea is then weighed and boxed for shipment (fig. 4).

The fruit evaporators made by the American Manufacturing Company have been most satisfactorily used at Pinehurst in drying tea. The moist tea is exposed to the highest temperature on the upper slides, and

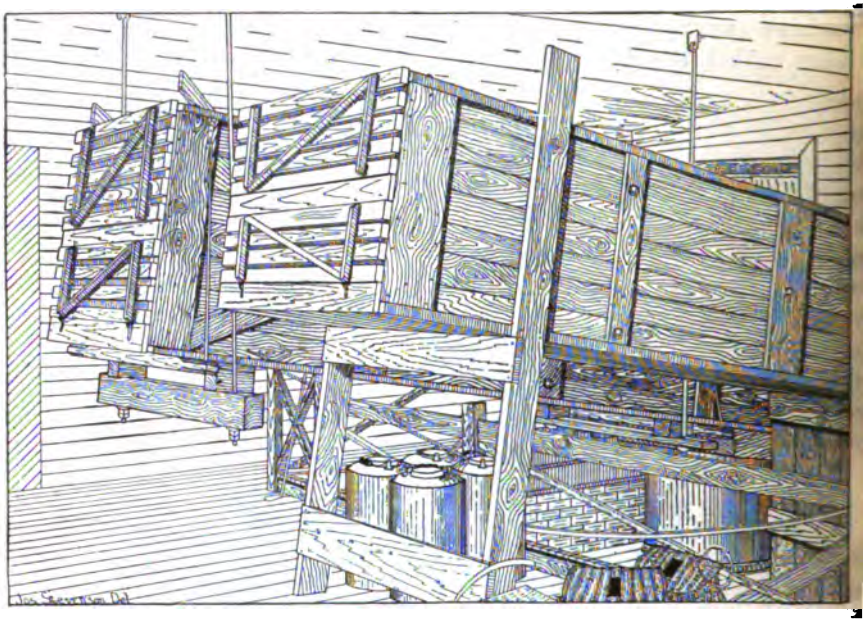


FIG. 3.—Drying machines for "firing" with hot air the rolled and oxidized leaf.

as it dries out it is gradually lowered to a cooler temperature, where it does not come in contact with escaping vapors—a great advantage.

FIG. 4.—Weighing and boxing finished tea; ends of driers in farther room.

DIFFICULTIES IN STARTING THE INDUSTRY.

Among the several difficulties which confront the establishment of this new industry in the Southern States, the following are the most important:

DEMAND FOR GREEN TEA.

(1) There is probably a greater demand in the United States for green than black tea. At present a large amount of sophisticated green tea is consumed in this country. As it is chiefly made of inferior leaf, highly colored with Prussian blue, and faced with powdered soapstone, etc., so as to hide all natural defects, it can not be regarded as either nutritious or healthful. But the nature of the demand indicates a decided preference for the taste and qualities of green, i. e., not oxidized, teas, and should stimulate us to supply in its stead a pure wholesome article of the same type. Unfortunately green teas can as yet be made by hand only; they represent cheap Oriental labor, and in the lower and medium grades competition by American manufacture is well-nigh impossible. Black teas can be made by machinery in almost every step after the delivery of the leaf in the factory.

COST OF LABOR.

(2) The cost of production of teas in this country is high, owing to the comparative dearness of labor. This must be met by a greater productiveness in the field; by the substitution of machinery for hand labor in the factory, and by the manufacture of varieties of teas which from inherent chemical causes can not be brought from the Orient.

As to a greater productiveness, one essential factor demands attention, viz, an abundance of the richest plant food, either natural or artificial. At Pinehurst the cost of enrichment by commercial manures amounts to 4½ cents per pound of the dry tea from the older fields. The amount of production of tea and cost of artificial manuring are as follows:

Production, cost, etc., of tea growing at Pinehurst.

Name of tea garden.	Variety of plant.	Location.	Age of garden.	Extent of garden.	Production of green leaf—1898.	Production of dry tea—1898.	Production of dry tea to the plant in 1898.	Cost of commercial manure to the lb. of dry tea.[1]	Remarks.
			Years.	*Acres.*	*Ounces.*	*Pounds.*	*Ounces.*	*Cents.*	
Rose	A. H.[2]	Drained pond	9	0.83	21,701½	323	5.57	2.3	Plants placed 6 feet apart.
Clay Hill	A. H.	Clayey hillside	9	1.50	12,631½	188	1.88	5.3	
Sand Hill	A. H.	Sandy level	9	0.66	6,950½	103¼	2.57	5.0	
North Bottom	A. H.	Cleared swamp	9	2.66	22,069	328	1.78	3.9	
South Bottom	A. H.	do	8	1.87	16,110	240	1.92	4.1	
South Fraser	Chinese.	Mostly clayey hill.	6	2.00	20,653	308	1.00	5	Plants 4 feet apart.
Lincoln	Darjeeling.	Drained pond	4	1.90	17,854	266	1.00	4	

[1] The fertilizer used contained 5 per cent available phosphoric acid, 5 per cent potash, and 5 per cent ammonia (chiefly from dried fish and red blood).

[2] A. H. refers to Assam-hybrid, mostly thoroughly acclimated tea, a cross of the Assam and Chinese sorts; and largely introduced into this country in the fifties.

As stated in the preceding table, based upon the operations of last autumn, the item of artificial manuring can be brought down to about 2 cents per pound of dry tea produced in a crop of over 300 pounds to the acre. By a suitable location on naturally very fertile lands the expenditure for manuring may be obviated, at least for some years, and a consequent saving of several cents per pound effected in the cost of production.

A greater productiveness per plant and per acre must lessen the cost of each pound of made tea, as it will reduce the distance to be traversed in picking the leaf. Incidentally it will permit for the same extent of gardens a reduction in the factory expenses, on the general principle that the greater the output the less the cost of the unit.

IRRIGATION.

Again, it will probably be possible to materially increase the productiveness of the tea gardens by irrigation. A comparison of the summer and annual rainfalls at Charleston with those of a number of prominent Oriental tea-growing districts shows that the latter receive not only a very much larger annual rainfall, but that the proportion which falls in the tea-growing period, from May to September, inclusive, is decidedly greater.

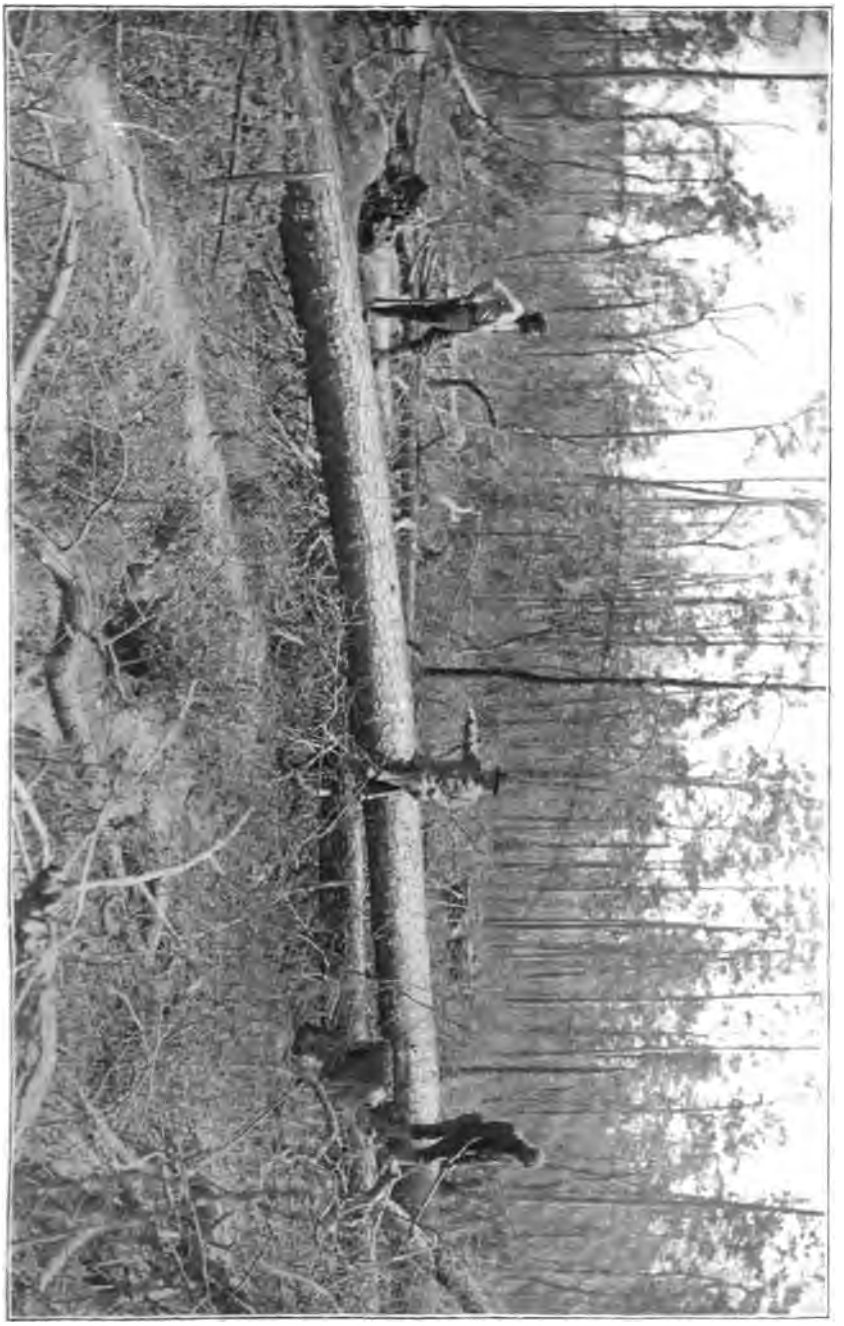
Comparison of rainfall at Charleston, S. C., with rainfall in India and China.

Locality.	Annual rainfall.	Rainfall May–September.	Relation of latter to former.
	Inches.	*Inches.*	*Per cent.*
Charleston, S. C	56.99	31.31	55
Goalparah, Assam	94.44	80.39	85
Leebsangor, Assam	90.45	66.48	73
Darjeeling	129.50	111.06	86
Canton and Macao, China	78.96	60.22	76

MAKING NEW GARDENS.

The work of establishing additional tea gardens for purely experimental purposes has progressed favorably. Under the auspices and with the pecuniary assistance of the U. S. Department of Agriculture the land have been cleaned of the dense forest growth which originally covered them (Pl. IX), thoroughly grubbed, and more or less leveled; treated with burnt marl at the rate of 1 ton to the acre to remove any sourness, and the preliminary steps taken toward supplying irrigation and subsoil drainage. The land has yet to be deeply plowed, and on the advent of the rainy season supplied with tea seedlings, of which there are many thousands in the nurseries. See Plate VI, figure 2.

This undertaking is, from the immediate surrounding conditions necessarily expensive; but considering the otherwise favorable circumstances and the prime importance of the experiment, the results should amply repay the cost. In this section of the Southern States there are



CLEARING GANTT'S FIELD PREPARATORY TO THE ESTABLISHMENT OF EXPERIMENTS WITH IRRIGATION ON TEA GARDENS.

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untless acres of rich lands, susceptible of irrigation, now only par-ially cultivated, which may be utilized for this new industry if the itial experiment proves satisfactory. And the recent evidence before e Industrial Commission reveals for many parts of the South a cuniary remuneration of labor on the farm not so much above that of e Oriental laborer as was formerly believed.

The Pinehurst experience is that moist, well-drained, level land is the st for tea. How much increase in the crop can be obtained by arti-ial irrigation remains to be seen; as also how much water it is desir-ble to apply. M. Martin states (Annales Agronomiques XIII) that ch plant requires about 13 gallons of water per week in the dry ason. If planted at 5 feet distances, a garden of an acre would thus quire 22,737 gallons weekly, or about four-fifths of an inch of water; d subsoil drainage is indispensable, even without any artificial ldition to the water supply.

MOST PROFITABLE FIELD.

The best Oriental teas are said to be only slightly "fired," i. e., they e dried at low temperatures, to preserve those volatile principles hich give them fragrance and delicacy of flavor. They will not bear stant transportation, if for no other reason, because they do not keep eir best qualities for a long period. They are readily worth from $5 $50 per pound in Japan and China, whereas the great bulk of the as which we import from those countries costs less than 15 cents per ound at the port of shipment.

Twenty dollars a pound for tea means a dime or less for a cup of e beverage; but that price, strange as it sounds in this country, uld not prove a barrier to the introduction of a grade of tea which ould otherwise not be obtainable. Herein lies a most profitable, if mited, field for experimentation, because there can be no competition om afar.

And it may be suggested that perhaps the best avenues for success e in the development of selection of long Pekoe tips for the manufac-ire of Mandarin tea, such as is made in China; and in the shielding f the tender leaf from the direct rays of the sun, as is done with mats Japan.

A PLEA FOR AMERICAN TEA.

The following article, prepared by the author for the Florida Times-Union, and published by that paper in 1897, treats of tea at length, and t has been thought advisable to reproduce it in full in this report:

Commercial tea is made from the leaves of the camellia thea. Formerly, when it as erroneously supposed that black and green teas were necessarily made from dif-erent plants, it was attempted to distinguish scientifically between the varieties sed in the production of each; for, although either sort may be made from the ame leaf, experience will show that each variety of the tea plant is better adapted or the manufacture of the one or the other.

Practically it is desirable to separate as distinct varieties the two most divergent types—viz, the Assamese and the Chinese—from the many intermediate sorts which have resulted from their hybridization or are the result of climatic and other influences upon them.

It is claimed that the original tea plant is indigenous to Assam, a province in northeastern British India. There in the jungles of the Brahmapootra River, in a hot, steaming atmosphere, where frost is unknown, shaded by lofty subtropical forests, were found tea trees attaining a height of 25 or more feet, clothed with large, lustrous, bright-green leaves, measuring 9 inches in length and 4 in width. It is believed by many that all cultivated tea owes its origin to this source, and that when its utility to man was recognized it was thence carried to the north and east, even to the remote and chilly northern islands of Japan.

The result of this climatic change was to stunt the plant and shrink the foliage to the small, dull-colored, lancet-shaped leaves characteristic of the variety generally (but with some injustice) called Chinese.

Thus the tea plant, although originally from a subtropical climate, can endure very considerable cold, even brief periods of ice and snow, but at the expense of its size and, as we shall see, utility. The converse is also true—that varieties which have suffered from cold, neglect, and insufficient nourishment readily respond to more favorable conditions. The Pinehurst experiments have amply demonstrated this fact.

FAVORABLE CONDITIONS.

It is generally held that certain natural conditions of climate and command of cheap labor are indispensable for the success of tea culture. Among the former are a uniformly warm but not excessively hot temperature, one quite free from frosts, and an abundant rainfall, its copiousness being directly proportional to the intensity of the heat; and as hand labor plays an important part in the tea industry, necessarily so in the plucking of the leaf, the cost of labor demands careful attention. To which supposed essentials may be added the necessity of a deep, rich, thoroughly drained soil, since the tea plant requires the most abundant sustenance.

It will be at once suggested that a great and apparently insuperable disparity exists in most of these prerequisites between the Oriental tea countries and the Southern United States. It is true that almost all of the latter country is liable to frost and certainly by far the greater part to occasional ice; that the average rainfall is only half of that in India, and that the price of labor is several times greater. Nevertheless, there are, as we think, substantial reasons why tea should be extensively cultivated in this country.

MAY BE CULTIVATED IN THE SOUTH.

It is not necessary that the annual rainfall should exceed 60 inches where the average temperature is less than 70° F., especially if the greater part of the yearly precipitation occurs in the growing season. This is true of Japan, China, the higher altitudes of Ceylon, and some districts of India, where altogether the greater part of the world's tea is produced. And by a proper treatment of the soil, by underdrainage, subsoil plowing, and deep pulverization, a gain of moisture equivalent to a fall of 10 to 15 inches of rain is secured. This effect is enhanced by planting cowpeas between the tea bushes, whose roots penetrate the soil and dying not only leave valuable food for the tea, but render the earth much more porous and capable of retaining moisture during seasons of drought.

Frost and brief periods of cold curtail the production of tea; but some of the choicest brands, particularly those of great flavor, come from climates whose temperature often falls in winter below 32° F. A decided gain in quality compensates for a lesser yield in quantity.

The several tea countries exhibit a marked difference in the production per bush. Thus, in India and Ceylon exceptionally productive estates enjoy a yield of 8 to 10

ounces of dry tea per bush; the general average being 3 to 4 ounces, and at the higher altitudes 2 to 3 ounces. In China the bush is said to produce 2 ounces, but only by a system of plucking which approaches stripping. In Japan the yield is 1 ounce or less. At Pinehurst, with fine picking (ordinary picking should give fully 50 per cent more), the "Rose Garden," planted with thoroughly acclimated Assam hybrids, gave this year (1897) 3 ounces per bush; a garden of Chinese origin, four-fifths of an ounce, and one of Japanese, one-half ounce. It is observable how the effect of the native climate follows the seed into even distant lands.

Very many crops are remuneratively grown out of their natural zones, and often with an improvement of the quality, although usually at enhanced cost of labor and attention. This is strikingly shown in the case of tea, in the higher valuation of the product of the Darjeeling gardens in India, as also of the more elevated ones in Ceylon, and of the black and green teas from the northern district of China (the home of the thea viridis). The higher price of labor in this section should not prove an insuperable obstacle to the cultivation of tea.

DUTIES MAY BE RESTORED.

Temporarily the tea market is depressed, and immense quantities of the cheaper sorts are being thrown upon us, especially as we impose no duty on tea. The United States stands alone among civilized nations in the latter respect. Free-trade Great Britain imposes a duty of 8 cents per pound on the tea from her own colonies, and they furnish almost all that she consumes. The continental European countries place on tea duties of from 20 to 40 cents. Russia, which proverbially enjoys the best tea, charges the highest rate.

Some years ago, when the war between the States necessitated additional revenue, there was a duty on tea of 25 and later 15 cents per pound. To-day the revenue of the Government does not cover its expenditures, and consequently there is frequent discussion of the advisability of restoring the duty. An increase of 20 cents per pound is equivalent to one-tenth of a cent per cup of tea, since a pound of good tea should suffice for 200 cups of the beverage. A duty of 20 cents per pound would more than compensate for the difference in the cost of labor on the middling and low-middling grades, which without national protection in the form of duty or bonus it would be folly to attempt to raise on a commercial scale in this country. It is surely coming—the duty on tea—and just as surely as this Government will go on spending more than it collects. A war or any other cause for extraordinary expenditure must promptly reinstate it.

But aside from possible remunerative conditions not as yet existing, it will pay to raise the better grades of tea in the Southern States wherever the climate and labor best subserve the purpose. We fully believe that we have demonstrated that fact at Pinehurst. There may be more promising undertakings; there may be regions where ample and profitable employment is enjoyed by all, with a reasonable outlook for the immediate future; but the writer does not know where they are. On the contrary, the population seems to be increasing more rapidly than the means of employment and sustenance; and, without regard to the question of the currency, the day is almost upon us when many must be idle unless new industries are provided. The cultivation of tea offers easy outdoor occupation for men incapable of hard labor in a hot, malarial region; it enables women and children to earn their livelihood, as they are compelled to do in all thickly inhabited countries. It is not a case of "half a loaf." According to our experience, ordinarily skillful and industrious laborers may be safely paid as much in tea gardens as in cotton, corn, or pea fields.

WHAT MAY NOW BE DONE.

There is a large class of people who might profitably add the cultivation of tea to that of flowers and vegetables, filling out the corners of their gardens and home fields with tea bushes, as they do in China, or substituting useful as well as ornamental

evergreen hedges of that plant for the present unsightly and costly and frequently unreliable fences. Cultivated in this way, the outlay of time, labor, and money could hardly prove burdensome; and, as one result, the household should be able to supply its own tea—pure, strong, and invigorating, instead of the wishy-washy, often far from cheap, stuff generally sold throughout the country.

As these little tea gardens are extended and multiply, factories will be established in each neighborhood for the larger manufacture of commercial tea, whither the products of the gardens surrounding may be brought and sold, precisely as canning factories and dairies consume the surplus production of fruit and milk.

One feature in the cultivation of tea has only to be stated to appeal to everyone who plants, namely, that the season for gathering the leaf lasts in this climate for six months. Thus a crop is not dependent for at least partial success upon the weather of any one or two months, as is so apt to be the case with most of the objects of the husbandman's labor and solicitude.

For the present it will be wiser to limit the production of tea in the South to the better grades, such as retail at from 50 cents to $1 per pound. The greater cost of unskilled labor in this country than in the Orient should constitute a smaller fraction of the total expense if the product commands a higher price. Other things being equal, the quality of any tea depends on the "fineness" of the leaf plucked. If only the tiny, tender, youngest leaf be picked, the quantity of the crop must be comparatively small; but its quality will be decidedly superior to that obtained by "coarse" plucking, which also embraces the older, larger, and necessarily tougher leaves.

A PLAN OF OPERATIONS.

In the selection of seed, it is desirable to procure the nearest approach to the Assam variety that the local climate will permit, if our object be to attain the greatest yield and strength consistent with quality; but it is to be remembered how exceedingly sensitive to cold is the indigenous Assam. If delicacy of flavor be sought, some of the Chinese or Indian hybrids will afford that, with a very fair leaf production. The intention of the grower to produce green or black tea will influence the selection of the seed. Here we have Assamese (at least some few that have survived the climate), Darjeeling, Kangra, Kumaon, Ceylon, Formosa, Chinese, and Japanese; also that Americanized stock which, from importations of many years ago (perhaps fifty), may be regarded as thoroughly acclimated. From all of these, except some Japanese, which we owe to that Government, and Formosan, better black than green tea can be made.

If foreign seed is desired, orders had better be sent to those who make a business of raising, selling, and shipping seed; otherwise there will ensue the natural disappointment from the loss of three out of four consignments, the consequence of ignorance and carelessness. The best seed comes from groves especially reserved for that purpose, and not subjected to the ordinary pruning and leaf plucking. The cost of 100 pounds Oriental tea seed, say 40,000 seeds, laid down here, will vary from $60 to $120, according to the quality and the expense of the transportation.

PLANTING THE SEED.

The sooner the seed is planted out, after maturing in the autumn, the better; and it is advisable to protect it in nurseries. Choose a thin, rather light soil, overlying a harder subsoil, with free drainage, near a spring or other water supply; spade the top soil to the depth of 6 inches; rake it off level; the surface should be rather below than above that of the surrounding land. Erect a frame and light cover of boards or boughs over the bed, as a protection from cold, but especially from direct sunlight. It should be sufficiently open to admit the rain. The underlying soil is left undisturbed, with the object of curtailing the growth of the taproot, which otherwise might suffer injury in the subsequent transplanting. Plant the seed 2 or 3 inches deep, at distances of 3 inches, in rows 4 inches or more apart; thoroughly wet the bed, and cover it with a few inches of pine straw or other litter.

If the rain be insufficient, thoroughly moisten the nursery bed, especially when the young seedlings begin to appear. Remove, then, almost all of the litter; keep the bed clean from weeds.

With the occurrence of the wet season in midsummer the seedlings should have attained a height of 4 to 6 inches, and are then ready for transplanting. This should be done with the ordinary strawberry transplanter. Good fresh domestic seed affords 75 per cent seedlings; but with importations from a great distance 25 per cent is a fair return, although we have occasionally germinated 60 per cent.

LAYING OUT THE GARDEN.

Select level land, naturally moist, but free from stagnant water; the soil should be light and porous, rich in thoroughly decomposed organic matter (preferably from oak leaves), and as deep as possible. The subsoil should be self-draining and present no obstacle to the deep penetration of the taproot.

Analyses of the best Indian tea soils show a great deficiency of lime, an absence of sulphuric acid, the constant occurrence of manganese, and a large amount of nitrogen, as also considerable quantities of potash and magnesia micas. The best Chinese, Japanese, and Javanese tea soils are said to contain a great deal of ferruginous clay, and to be likewise deficient in lime. The high quality of the Formosa tea has been attributed to the large content of iron in the soil. At Pinehurst experiments have been conducted on sandy, clayey, and bottom lands; on level fields, on hillsides, and in drained ponds, with the result that we earnestly recommend level lands thoroughly drained, porous to as great a depth as possible, and sweet, i. e., free from all virginal acidity. It was early recognized that none of our lands afforded sufficiently abundant and quick plant food to stimulate and maintain that unusually luxuriant growth which is indispensable in a successful tea garden. Consequently, all have received abundant enrichment. The chief question presented to us seemed to be whether a tea industry could be inaugurated here on a profitable basis, and minor considerations had to be postponed. The difference in the yield of the several gardens is to be attributed to the unequal productive habits of the different sorts and to the varying physical conditions of the lands. Nevertheless, as regards the former, it is noticeable how quickly the tea plant responds to generous treatment and returns full payment therefor in quantity and quality. With this increased vigor comes a tendency toward a type characteristic of the local climate; and, as a consequence, experts have appreciated and styled as "South Carolina" the flavor which belongs to the Pinehurst tea.

It has been found desirable to plant at greater distances than is common in the East, so that draft animals and the usual cultivators may be substituted as far as possible for hand labor, such as obtains in cheap-labor countries. Tea is usually planted in rows. The plants may be at distances of 4 feet or more, according to the size of the kind, laid out rectangularly or by alternate planting ("quincunx"), as used in some Florida orange groves, whereby three-way plowing is secured, or hedges may be formed by planting at 12 to 18 inches apart, with alleys of 5 or more feet between them. The latter system involves more hoeing, but can be advantageously used on slopes, to prevent the washing away of the soil. We have also planted seed "at the stake;" that is, where the garden is to be formed and the tea bushes to stand, but the nursery method is preferable.

Each seedling should receive the protection, from the sun and cold winds, of two shingles; in summer they are placed to the south and west and in winter to the north and west.

CULTIVATION.

Keep the young plants growing by any and all good agricultural methods, otherwise leave them alone, unless it be to pinch back any excessive upward growth. As a rule, it will be well to defer any excessive leaf plucking until the third year; nevertheless we have made about 50 pounds of tea to the acre from 2-year-old gardens

without detriment. Vacancies caused by the death of individual plants should be filled as early as possible from surplus stock left in the nursery.

The manures employed at Pinehurst are carefully preserved stable compost (fortified with acid phosphate and kainit) wherever it can be profitably utilized, and commercial fertilizers rich in soluble potash and available nitrogen, with a modicum of soluble phosphates. New land gets with us a heavy dressing of burned marl in advance of cultivation. The tea plant demands the richest of food and plenty of it. In the autumn cowpeas are sown in the alleys.

THE CROP.

Leaf-plucking demands the careful attention of the tea grower. It is a light employment, suitable for women and children, but they must be patiently taught, and their work must be strictly scrutinized. At Pinehurst colored children do the picking, and very satisfactorily. A free school (Pl. VII, fig. 2) is maintained for them; every pupil of suitable age and size is required to pick; others are excluded from the gardens. Regular attendance and better discipline are thus secured. But, otherwise, there would be no difficulty in securing an ample force, as the wages earned prove in themselves a sufficient attraction. The older children earn from 30 to 50 cents a day; the younger ones in proportion. During the past season the tea gardens were picked twenty times, or once every ten days, and it took three days for the average force of twenty children to make the round of the gardens. The more industrious and skillful pick from 10 to 20 pounds of fresh leaf per diem. It takes 4½ pounds of fresh leaf to make 1 of dry tea.

FLUSHES.

The growing tea plant throws out from its branches tender, bright shoots. On examination these are found to consist of a tiny, tender, unexpanded leaf bud at the end of the shoot (the so-called Pekoe tip, or flowery Pekoe); an almost equally tender, small leaf follows on the stem (the orange Pekoe), and then one slightly larger and firmer (the Pekoe). The bud and two leaves furnish Pekoe tea. Following them come two yet larger and more mature leaves, the first and second Souchong; and the twig has often two more still.

In the axis of each leaf, that is, between it and the stem, may be seen a diminutive leaf bud, which, on proper encouragement, will rapidly produce another wholly-equipped shoot. This encouragement is afforded by furnishing such a stimulus to luxuriant growth that its existent foliage fails to meet the demands of the plant, or by artificially depriving it of the greater part of its leaves. These new shoots constitute a "flush;" and as each shoot has several leaf buds, it will be seen how rapidly the work of restoring the natural equilibrium can proceed.

The cultivated Assamese variety is capable of bearing twenty or more flushes in the season; the Chinese and Japanese, only a few. On young plants and with the earliest spring flushes of older gardens the pickers are taught to nip off between the thumb nail and forefinger the Pekoe tip and three-quarters of the orange Pekoe leaf. As the season advances and more leaf may be safely picked, three-quarters of the Pekoe leaf are additionally taken. Thus two leaf buds are left at the end of the shoot for producing others in due time. At the height of the season we sometimes pluck three-quarters of the first Souchong, if quite tender.

This constitutes fine picking; hence the strength and flavor of the Pinehurst tea. In other countries both of the Souchongs are usually picked, and in China, at the summer crop, almost all, if not quite all, of the young shoots is taken.

The children put the leaf into Swiss trout baskets. They are not permitted to pack it down tightly, for fear of its becoming heated. Nor is it allowed to collect in large quantities in the field, but is brought to the factory, very carefully examined as to fineness and general condition, weighed, and spread out on a cool, clean floor.

PRUNING.

When the tea bush has lost its youthful vigor, when the intervals between the flushes are protracted, or the growth has become too tall and irregular, perhaps entangled, then pruning becomes necessary. This step consists in the moderate or occasionally rigorous cutting back of the foliage, so as to force a long succession of flushes. It should be done in the winter, and a bush severely pruned at that time should receive only mild picking during the ensuing spring and early summer. The production of leaf on even the most luxuriant types of tea is but scant if they be left to themselves in their native jungles, whereas if introduced into the open sunlight, and properly pruned and cultivated, they become capable of an enormous yield. Nor does intensive cultivation and cropping, judiciously exercised, appear seriously to impair their strength and life. The importance of this step was quickly appreciated by that veteran horticulturist, William Saunders, of the National Department of Agriculture, on his official inspection of the Pinehurst tea gardens during the past summer. In his report to the Secretary of Agriculture he wrote:

"The first garden visited at Pinehurst in company with Dr. Shepard was one of about 2 acres in extent, where the pickers were busy collecting a 'flush.' Having grown many thousands of tea plants, and being familiar with methods of culture in India, so far as verbal information from growers and illustrations could convey ideas of management, the writer saw at first glance that he was looking upon a tea garden of perfect cultivation. The first attraction of such a garden is the remarkable color of the foliage, a deep, velvety green, shining with vigorous health on the lower leaves of the plants. The uniformity and perfection of shape of the plants, indicative of skillful pruning, is next noticeable. Skill in pruning is also apparent in the vigorous growth of the young shoots, giving succulency to the leaf and promoting rapid development of continuous flushings. All these features combine to form a scene of uncommon interest of the appreciative observer.

"No single operation in the management of tea gardens at Pinehurst is more interesting to a practical plant grower than the system of pruning. This has been reached after a long study of various methods, some of which have proved disastrous.

"Here the pruning is directed first to the gradual extension of the breadth of the plant without greatly increasing its height, but increasing the number of shoots available for picking; and, second, to secure strength in these shoots, so that their vigor is maintained up to the last flush, and they are able to respond quickly in the production of new leaves after each picking."

MANUFACTURE.

There are very many commercial teas. Prominent and most divergent are the so-called green and black; the intermediate ones are numerous. Two processes are requisite in the manufacture of all teas, viz, rolling or other manipulation, whereby the leaves are preserved and the oily cells in the leaves are broken and their contents rendered easily extractable by hot water, and drying, whereby the tea is preserved. In the manufacture of green tea these operations suffice, and they should be performed with celerity, so as to prevent the action of the atmospheric oxygen upon the leaf. In making black tea two additional steps are necessary, viz, withering, whereby the leaf is prepared for rolling, and oxidation (formerly thought to be a fermentation), whereby certain chemical changes are induced. It is not intended to enter upon the description of the manufacture of tea in this article, already perhaps too long. There will be abundant time to thoroughly study and provide for its various operations before the tea plantations, which the writer hopes to see started in Florida, are ready to furnish leaf. That he is a firm believer in the future, if not the present, of American tea his 50 acres of tea gardens attest.

CHARLES U. SHEPARD.

PINEHURST, SUMMERVILLE, S. C.

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U. S. DEPARTMENT OF AGRICULTURE.

Report No. 62.

CULTIVATION

OF

CIGAR-LEAF TOBACCO IN FLORIDA.

BY

MARCUS L. FLOYD,
OF THE DIVISION OF SOILS,
IN COOPERATION WITH THE DIVISION OF VEGETABLE PHYSIOLOGY AND PATHOLOGY.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1899.

RECENT PUBLICATIONS OF THE DEPARTMENT ON TOBACCO.

Bulletin No. 11, Division of Soils.—Tobacco Soils of the United States, a Preliminary Report upon the Soils of the Principal Tobacco Districts, by Milton Whitney, Chief of Division of Soils.

Farmers' Bulletin No. 60.—Methods of Curing Tobacco (revised edition), by Milton Whitney, Chief of Division of Soils.

Farmers' Bulletin No. 82.—The Culture of Tobacco, by Otto Carl Butterweck.

Farmers' Bulletin No. 83.—Tobacco Soils, by Milton Whitney, Chief of Division of Soils.

Cultivation of Tobacco in Sumatra, by Emile Mulder.

[1] *Report No. 59.*—Curing and Fermentation of Cigar-leaf Tobacco, by Dr. Oscar Loew, of the Division of Vegetable Physiology and Pathology.

Report No. 60.—Temperature Changes in Fermenting Piles of Cigar-leaf Tobacco, by Milton Whitney and Thos. H. Means, of the Division of Soils.

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[1] Since its establishment in 1862 the Department of Agriculture has issued various publications of a miscellaneous character not properly belonging to any of its established series, which have, up to the present time, remained practically unclassified. These publications, fifty-eight in number, have heretofore been known as "unnumbered reports," and are herewith brought into a series and assigned numbers—1 to 58.

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
DIVISION OF SOILS,
Washington, D. C., July 29, 1899.

SIR: In pursuance of the work of this Division, and in order to interpret the results obtained in the investigation of the tobacco soils of the United States, particularly to determine whether the crops produced on the types of the tobacco soils are the best obtainable with our present knowledge and skill in manipulation, it seemed advisable to add to the staff of this Division a person trained by experience in the tobacco business.

In reviewing the situation carefully it seemed evident that the most striking advances in recent years have been made in the development of the cigar-tobacco industry of Florida. A request was therefore made on the Civil Service Commission to establish an eligible register of those who had thorough knowledge of the Florida methods and who had had experience in the development of the industry there. Mr. M. L. Floyd, of Quincy, Fla., was appointed tobacco expert in this Division as a result of this examination.

The present development of the tobacco industry in Florida was started about twelve years ago by several prominent New York firms. In 1888 Mr. Floyd assumed general charge of the operations in Florida of one of these firms, producing the first year 25,000 pounds of tobacco and purchasing from the farmers 200,000 pounds for fermentation and packing. In 1894 he took a similar position with another firm in Quincy, at that time planting from 800 to 1,000 acres in tobacco and buying extensively from the farmers. Thus for many years he was connected with two of the largest firms operating tobacco plantations in Florida. He had general oversight of the plantations and of the manipulation of the tobacco in the barns and curing sheds, and has also assisted in selling the tobacco after it had been fermented and packed. In 1897 he secured a packing house of his own and was in business for himself up to the time of his connection with this Department.

The work of the Florida growers, while essentially practical, has really been developed along scientific lines.

The accompanying manuscript embodies the results of Mr. Floyd's knowledge and experience, and its publication is recommended as Report No. 62 of this Department.

Respectfully,

MILTON WHITNEY,
Chief of Division, in Charge of Tobacco Investigations.

Hon. JAMES WILSON,
Secretary of Agriculture.

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CULTIVATION OF CIGAR-LEAF TOBACCO IN FLORIDA.

REQUIREMENTS OF THE CIGAR-LEAF TRADE.

The demand of the trade for cigar-leaf tobacco is exceedingly vacillating. This is very apparent to the man who goes out on the road to sell tobacco. There is hardly a class of men in any one line of business so much at variance in their opinions and wants as the dealers in and the manufacturers of cigar-leaf tobacco. In view of the fact that we have not yet arrived at the point in cultivation where any section produces a uniform lot of tobacco, perhaps this difference of opinion and variety of qualities desired on the part of the dealer and manufacturer is a good thing, as we can be sure that, no matter what we have so long as it is really tobacco, we can find a manufacturer who can and will use it, provided the price is low enough. There are stogies, cheroots, and a world of low-grade cigars consumed each year, and to produce tobacco suitable for these goods we need make no special effort. What we want is to produce a tobacco for a cigar of better grade and higher price.

All are fairly well agreed that for wrapper purposes the Sumatra furnishes the ideal leaf, while for fillers, where quality is needed, the island of Cuba produces the best leaf. As these tobaccos are the standard of quality and style sought after, it should be the aim of each tobacco-growing section to produce as nearly as possible a tobacco that will take the place of these imported goods, both in appearance and quality. The first essential in all cases is that the tobacco, whether wrapper or filler, burn smoothly and freely. Next there must be quality; the taste must be pleasant, not rank and strong, nor too mild. When the taste is pleasant, not sharp, the aroma will invariably be good. The cigar that possesses the above qualities will please the smoker and leave him wanting another, and thus the manufacturer will also be pleased. The wrapper must have style. At present the Sumatra is the standard by which all other wrapper leaf is compared, both as to quality and appearance. That means that a wrapper, to be acceptable to the manufacturer of the high-grade cigars, must be light in color, rich in grain, thin in texture, small in vein and stem, very elastic, and of good burning quality. The most desirable

sizes are 16 and 18 inch leaves, as from leaves of these sizes the manufacturer will get four wrappers from each leaf and have very little waste, which is always quite an important item to consider. We will assume, for illustration, that a manufacturer buys 2 pounds of Sumatra wrappers for which he pays $4 per pound. These 2 pounds will wrap 1,000 cigars, all "first," at a total cost of $8. There is no loss, the entire leaf being used as a wrapper, and the manufacturer has the satisfaction of knowing that for each 2 pounds of Sumatra wrapper bought 1,000 cigars will be wrapped and will be uniform in color.

Whenever we can produce in this country a wrapper that will come up to the above requirements, we shall find that the trade will take it and pay liberally for it, but as long as we offer to the trade inferior goods the prices will be low. Of course the first essential is that the wrapper leaf be grown; the next is that it be properly cured, assorted, and classified. A manufacturer will never pay a high price for a bale of tobacco unless he can calculate just what it will yield him, and this he can only do when it is well and carefully selected. The tobacco should be uniform in size, color, and texture, as when a bale of tobacco contains a variety of colors, sizes, and textures, the buyer is left to guess its value, and the price will necessarily be low.

For filler purposes, Cuban tobacco makes the standard. The size of the leaf should be from 12 to 14 inches, not longer, and it should not be very dark and heavy, as many seem to think, but of medium body and of a rich brown color, burning smoothly and freely. All manufacturers agree that it is never well to make a cigar from only one kind of tobacco; that is, a cigar should not be made in which the entire filler is Ohio, Pennsylvania, or Florida tobacco, but tobacco should be taken from these various sections and a combination tried until tobaccos are found that blend well. When this result is secured the combination is adopted and a new brand of cigar is put on the market. This is especially true of the Cuban tobacco. Many of the manufacturers would gladly reduce the amount of imported Cuban tobacco if they could be supplied with a domestic tobacco that would blend well with it.

We have no choice in the matter. The trade demands the quality contained in the Cuban tobacco and the style of the Sumatra leaf, therefore we must try to produce what they want. The tobaccos produced in the States of Pennsylvania, Ohio, and Wisconsin, and in the Connecticut Valley, go far toward supplying the manufacturers of our country; but unfortunately these goods find their way into medium and low-priced cigars, and our higher-priced and best cigars are made from imported goods. Just where the fault lies and what is the remedy is hard to say.

This much, however, can be said of some of the States, especially of Massachusetts and Connecticut—that a very pretty leaf is produced which one would think would be acceptable to the trade and find a place in the higher-priced cigars, but such is not the case except to a limited degree. Some manufacturers do use the Connecticut wrapper

on fine cigars, getting about two wrappers from or near the point of the leaf, where it has a rich grain. The remainder of the leaf being sleek and glossy—looking "seedy," as the manufacturer would say—can only be used on medium and low-priced cigars. The Zimmer Spanish and Little Dutch produced in Ohio make a good fight for a place in the medium-priced stock and are very acceptable to the smoker on 5-cent cigars.

For the past ten years Florida has done much to show what could and should be done. Finding that the trade could not be forced into taking whatever might be produced, it was determined to grow as nearly as possible a tobacco similar both in appearance and quality to that grown on the islands of Sumatra and Cuba. To do this the best seed obtainable was secured from these islands, and, as far as practicable, their methods of cultivation, harvesting, fermenting, and manipulation were employed. How well these efforts have succeeded may be judged from the fact that Florida fillers, when well cured and baled, bring to-day as high as 45 cents per pound, while wrappers bring from 50 cents to $2 per pound, according to style and quality.

This applies to the Cuban variety. So far as the production of the Sumatra type of tobacco in Florida is concerned, there is equal assurance of success. Unquestionably bales of that type of tobacco have been grown and packed that the best experts could not distinguish from the imported goods, and some of this, grown under shade, has been sold for $4 per pound. Of course these bales contain tobacco that has been selected with great care, each leaf being perfect. Two pounds of such tobacco would wrap 1,000 cigars, all "first," and equal to those wrapped with imported goods. This shows that when we offer to the trade the proper goods it is willing to pay for them. We have much yet to learn, as the per cent of this finer grade of wrapper has been very small compared with the quantity grown, thus causing the selection and classification of tobacco to be very expensive, as it requires the assorting of a large quantity in order to obtain a very small percentage of desirable wrapper leaf. However, as before stated, we have met with sufficient success to warrant the belief that in the near future we will produce a leaf that will take the place of the imported Sumatra. What may seem strange regarding the Florida-grown Sumatra is that from the same crop we are able to obtain light spotted leaves that are identical with the imported Sumatra, also light unspotted leaves that closely resemble the finest type of wrapper grown on the island of Cuba, each possessing the rich grain and general appearance of the imported goods.

All this is written relative to Florida in order to show that a high price can only be obtained when we offer to the trade a tobacco which resembles and will, in a great measure, take the place of the goods imported from Cuba and Sumatra. Undoubtedly Florida is gradually approaching this condition. It is a fact that during the past two years

much of the tobacco grown in all parts of the State has had no ready sale, and many of the growers have become discouraged. This, however, is due to the fact that the growers are inexperienced as to the culture, harvesting, and general care necessary for the production of fine tobacco.

From the foregoing statements it can be seen that the cigar trade, as applied to the higher-grade goods, demands the quality of the Cuban tobacco and the style of the Sumatra leaf. With these facts before us, it is unquestionably the duty of each tobacco-growing section to try to produce a tobacco that will meet these requirements. While we may not hope to entirely displace the Cuban fillers, we certainly can hope to produce a filler that will blend well with these goods, and thus greatly reduce the quantity of Cuban tobacco imported into this country.

CULTIVATION OF CUBAN TOBACCO IN FLORIDA.

The land for the seed bed should preferably be fresh, rich hammock, having a light gray soil, moist but not wet. Dry, thirsty land should be avoided. One hundred square yards of seed bed are necessary for each acre to be grown, and two tablespoonfuls of seed are needed to sow this area. If fresh hammock is available, the timber should be cut in November or December and the wood stacked, so that it will dry and be ready for burning when the seed bed is made. The time for sowing the seed is from January 15 to March 1. About one week before sowing the seed the bed should be thoroughly cleaned, and all straw and leaves carefully raked off, after which the ground should be "burned." This burning is done for two reasons; first, to destroy all grass or weed seeds or roots that might otherwise come up and choke the tobacco plants; second, to obtain the fertilizing properties of the hard wood. It is done in the following manner:

After raking the surface of the land well, skids are laid 4 feet apart, running the full length of the plot to be sown. A pile of wood is then laid across the skids, running the full width of the bed. The fire is started, and as fast as the ground is thoroughly burned and covered with ashes the fire and wood are drawn along the skids, wood being continuously added. The fire is moved along the skids until the entire bed has been burned, after which the ground is again raked to remove the coals, letting the ashes remain. The soil is then spaded to a depth of about 4 inches, carefully taking out all roots and tufts. If the soil needs fertilizing after the spading is completed (the seed bed should be very rich in order to give thrifty, healthy plants), such quantity of fertilizer as may seem necessary is sown broadcast over the surface. Any complete guano may be used. The bed is again raked with an iron-toothed rake to mix the fertilizer well with the soil and to have the surface smooth and loose.

The bed is divided into "lands" about 4 feet wide, leaving narrow s between. Each land is measured, to see how many square

FIG. 1.—SEED BED WITH PART OF THE CANVAS COVER REMOVED AS THE PLANTS ARE READY TO BE RESET.

FIG. 2.—PART OF A 10-ACRE TOBACCO FIELD WITH PLANTS JUST SET.

The whole is covered with cheese cloth fastened to wires running across the wooden frame, the frame being 9 feet high.

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feet it contains, and enough seed is mixed with ashes to sow one land at a time at the rate of 2 tablespoonfuls to each 100 square yards. After the sowing is completed a heavy roller is drawn over the bed, thus packing the seed well into the soil, making the surface smooth, and preventing the rapid drying out of the surface, that would otherwise take place. If the ground is dry, it should be watered immediately after sowing the seed, and this should be continued from time to time as the soil may require. In the absence of rain after the plants are up the watering should be continued. An illustration of one of the seed beds is given in Plate I, fig. 1.

There are many enemies to the seed bed in the way of insects, so a careful watch is necessary. As soon as there is any appearance of flea-beetles or horn worms it is the practice to spray the bed with Paris green mixed with water, at the rate of one teaspoonful to two gallons of water. In order to keep down all insects the bed is sprayed at least three times a week. It is usual to have plants large enough to transplant within sixty or seventy days from the time of sowing the bed. This applies to the January and February sowings; March and April sowings will give plants from forty to sixty days after being sown. The sowings are arranged according to what the requirements are likely to be in the planting season. In selecting early seed beds, it is best to get lands sloping from north to south, protected on the north by forests and open on the south to let in the midday sun. It is safer to protect these early beds by covering them with cheese cloth stretched on frames made around and over the beds. (Pl. I.)

When the plants are drawn for transplanting, great care should be taken to get as much root as possible. Each person drawing plants should be provided with a bucket of water, and as soon as the plants are drawn the roots should be washed to remove all dirt that may have stuck to them. The plants are then placed in a basket, roots down, and immediately set out. This washing of the roots is not generally practiced, but it has been found that the plants live and grow better when the roots are clean. After each drawing of the plants from a bed the soil should be immediately watered, in order to close up the places from which the plants were drawn. After all the plants have been drawn from the beds, all vegetation should at once be cut down and the bed covered with straw and leaves to a depth of about 6 inches. This covering prevents the grass, weeds, etc., from growing and also serves as a mulch. With this care a plot of land may be used for several years for the growing of plants.

FIELD CULTURE.

The soil selected should be light, gray, sandy loam with clay subsoil. The land should be broken up in November or December, allowing the plow to cut from 4 to 6 inches deep, according to the nature of the soil and the quantity of fertilizer used. If a large quantity of fertilizer is

used, such as cotton seed and stable or barn manure, it should be thrown broadcast over the surface and plowed in. This should be done about six weeks before the time of setting out the plants. About one week before setting the plants the land is laid off in rows 4 feet apart, listed with 2 furrows, thus making a ridge on which to set the plants. On the morning before setting out the plants the top of this ridge is made flat and smooth by means of a hoe or by a board attached to a plow drawn over the ridge. This leaves the top of the ridge flat and smooth and ready to receive the plants, which should immediately be set about 14 inches apart in the drill. As it is always desirable to get a uniform growth, great care should be exercised to have each plant live. Replanting should be done as quickly as it is possible to determine where fresh plants are needed. If the ground is moist and showers frequent, watering the plants is unnecessary, but if the ground is dry they should be watered immediately after setting and each day thereafter as long as the plants require it. The quantity of water used is in all cases governed by the condition and nature of the soil. After setting, the plants should not be disturbed for at least six days. If the soil becomes packed and hard, a furrow should be run on each side of the row, using a small straight plow and letting it run well down. This should be followed immediately by two sweep furrows, which will put the plants on a smooth ridge. The hoe is then used, carefully stirring the soil about the plants. From this point on the cultivation should be rapid and shallow. When the plants begin to "button" cultivation should stop. Early or low topping is not desirable, as it throws too much growth in the leaves, making them large and coarse. There should be 14 to 16 leaves to the stalk after a plant is topped. After the plants are topped, suckers will start at each leaf. These must be broken off at least twice each week. Of course in plowing and hoeing great care is exercised to preserve the soundness of the leaves.

The battle with the worm begins in the seed bed and does not end until the tobacco is harvested. As soon as the plant begins to grow after being transplanted, a preparation is made of Paris green and meal, mixed well together, at the rate of one tablespoonful of Paris green to one gallon of meal. This is sprinkled directly in the bud of the plant, and its use is continued until the plant is topped. By applying this with great care twice a week the bud worm, which is the greatest enemy of the crop, is kept off. The horn worm is also a great pest. Poisoning is resorted to in order to get rid of it, using cobalt and strychnine mixed with honey. One drop of this mixture is put in each blossom of the Jamestown weed. The blossoms are distributed over the fields in little stands prepared for this purpose, the stands being about 6 feet high, so as to enable the blossoms to be seen above the tobacco plants. The horn-fly is attracted to the blossom, and one sip of its poisoned contents proves deadly. In this way many of the horn

FIG. 1.—PART OF A 10-ACRE TOBACCO FIELD COVERED WITH CHEESE CLOTH, SHOWING THE DETAILS OF THE OUTSIDE STRUCTURE OF THE FRAME.

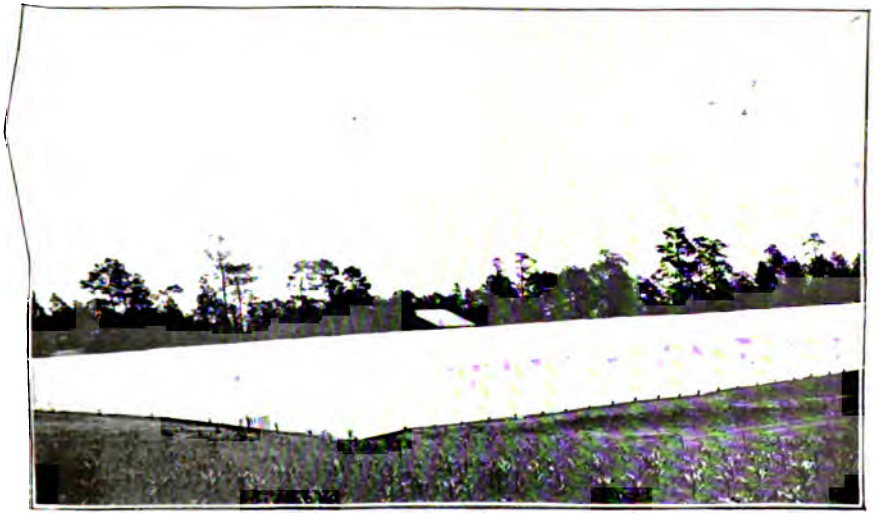


FIG. 2.—THE OUTSIDE OF A 10-ACRE TOBACCO FIELD COVERED WITH CHEESE CLOTH.
From an elevation some distance away.

flies are destroyed. However, as this means of extermination can not be depended upon entirely, a force of help is kept continually going over the field picking off the worms.

HARVESTING.

As soon as the first leaves at the bottom of the stalk begin to ripen harvesting is begun by plucking off the first four leaves from the bottom and transporting them to the curing sheds in baskets. These baskets are 36 inches long, 18 inches wide, and 12 inches deep, holding about 600 leaves, or enough to fill 20 laths. These baskets are carried from the field to the curing shed by men, if the curing shed is near; if not, they are carried in wagons. Each wagon has a frame that will carry 16 of these baskets, thus in one load transporting 9,600 leaves, enough to fill 220 laths. On reaching the curing sheds these baskets are received by the foreman of the barn work, who places them on tables, around which he has a number of women engaged in "stringing." They take the tobacco from the baskets and put it on strings by means of large needles. The leaves are placed back to back and face to face. This is done to prevent the leaves from cupping or folding over each other. Thirty-five or 40 leaves are put on one string, according to the size of the leaf. Each end of the string, as soon as filled, is attached to a lath 4 feet 4 inches long, and the leaves are evenly distributed along the string. The lath is then hung in the barn, where it remains until the leaves are cured. The method of stringing the leaves is shown in Plate IV, fig. 2.

If the tobacco gives promise of being "wrapper," that is, if it is light green, very sound in leaf, and of desirable size, it should be "primed" at an early stage of ripening. If, however, appearances indicate that it will prove "filler" tobacco, it should be allowed to thoroughly ripen. After priming six or eight leaves the remainder will ripen sufficiently near the same time to permit the cutting of the stalks. When the stalk is cut it is placed on what is called a hand barrow, carried by two men. These barrows will hold about eighty stalks, or enough to fill ten laths. On reaching the barn these barrows are placed on a table and the stalks are immediately put on laths by means of a spear fitted on the end of the lath, eight or ten stalks being put on each lath. These laths are then put in the barn just where they will remain until the tobacco is cured.

If the soil is rich and the season propitious a second profitable crop can be produced from the suckers. As soon as the original crop is topped suckers will sprout from each leaf. These, of course, should be broken off as soon as they appear, otherwise they will sap, hinder, and check the growth of the leaves. When all of the leaves have been primed from the original stalk, except the four or six leaves at the top, two suckers should be allowed to grow from the bottom of the stalk. These two will be well started by the time the top leaves of the original

stalk are ripe. The stalk should then be cut just above where the suckers sprout and cultivation should begin at once, the soil being brought up around the old stubble. The suckers should not be allowed to have more than six leaves each. The growth of these will be rapid and they will mature quickly. When ripe the leaves should not be primed, but the stalks should be cut. It is often the case, where the seasons are favorable, that the suckers will be very fine in quality for filler purposes. Where the original crop yields 600 pounds per acre it is often the case that 400 pounds can be produced from the second growth or sucker crop. As soon as all of the tobacco is harvested, the stubble is dug or pulled up and the field sown in cowpeas. In about three weeks the pea vines will cover the ground, thus protecting it from the midsummer sun. In the fall the vines are plowed under and prove of great benefit to the soil.

CURING.

When the tobacco is primed from the stalk it should not take longer than two weeks to cure; when hung on the stalks three or four weeks are necessary. The manipulation of the barn or curing shed is entirely governed by the condition of the weather and the nature of the tobacco, and no fixed rule or rules can be given. However, in a general way it may be said that if a barn is filled with green tobacco, and the weather is hot and dry, the ventilators should be tightly closed for about three days, by which time the tobacco will be quite yellow. The barn should then be opened at night and kept closed during the day. This is done to prevent rapid curing, as rapid curing destroys the life of the leaf and gives uneven colors. If there are frequent showers and but little sunshine, the barn should be closed and fires started in small charcoal heaters distributed throughout the barn. These fires should be continued as long as is necessary to keep the barn in proper condition. Where the charcoal heaters are not available, wood, which has little odor and as little smoke as possible should be used as the smoke is taken up by the tobacco and the odor of it is noticeable long after the tobacco is cured. It is very important to dry out the barn without giving the tobacco any foreign odors. To obtain the best results the tobacco should become fairly moist and be fairly dried out once in every twenty-four hours.

When the stems of the leaves are thoroughly cured they are ready to be taken to the packing house. To get the tobacco in a condition to be handled all of the places for ventilation are left open for one night, opening them about 6 o'clock in the evening. The next morning the tobacco will be in what is called "good case;" that is, it will have taken up moisture and become soft and pliable. The barn is then tightly closed in order to retain the moisture. The tobacco is taken from the poles and stripped from the stalk or taken from the string, as the case may be, and is packed in bundles that weigh from 35 to 40

FIG. 2.—SUMATRA TOBACCO UNDER CHEESE CLOTH, WITH PLANTS MATURING.

pounds. These bundles are made by means of a box 30 inches long, 12 inches wide, and 12 inches deep. Strings are placed at even distances across the box and pressed down well into little notches cut in the edge of the side. A sheet of paper, 28 inches by 50 inches, is then laid inside the box, on which the tobacco is put, placing the heads of the leaves to each end of the box and allowing the tips to lap in the center. When the box is well filled the paper is folded over the top and the strings securely tied. This gives a neat and easily handled package. In this condition it is delivered to the packing house as quickly as possible. In the barn the following grades are kept separate—bottom leaves, middle leaves, and top leaves—each package being marked to show its contents. This ends the work of the farmer.

CULTIVATION OF SUMATRA TOBACCO IN FLORIDA.

SELECTION AND PREPARATION OF SEED BED.

All that has been written relative to the selection of the land and the preparation of seed beds for the Cuban tobacco applies to the Sumatra as well, except that the Sumatra beds are sown later. It is the aim of the farmer to get all of the Cuban crop set out by May 15, about which time the setting of the Sumatra crop begins. The setting of the Sumatra crop is finished about the 15th or 20th of June. All the seed beds must be sown with the view of having the plants when needed.

FIELD WORK.

New, low hammock is decidedly the best land on which to grow Sumatra tobacco. The soil should be light gray with a clay subsoil. Sumatra tobacco must have a rapid growth in order to produce light, thin wrappers, and if the land is not rich it must be made so by fertilizers. A little complete guano, not exceeding 200 pounds per acre, may be used to stimulate the plants at the early stage of growth. Cotton seed, cotton-seed meal, and cotton-seed hull ashes are generally considered the best fertilizers for tobacco. If a great quantity of cotton seed is used it should be crushed and scattered broadcast over the land and plowed in. This is done about six weeks before the time for setting the plants. The quantity of fertilizer is governed in all cases by the original strength of the land. When not more than 75 or 100 bushels of cotton-seed per acre are used they are put in the drill. This is done by bedding out the land about four weeks before the time of setting the plants, immediately after which the fertilizer is evenly distributed along the water furrow and covered with two furrows. This is allowed to remain about three weeks, when a 10-inch solid sweep is used to break out the list in which the fertilizer has been put, letting the plow run well down, thus mixing the fertilizer with the soil. This furrow is followed immediately by two other furrows, throwing the soil back and making a ridge on which to set the plants. Before setting out the plants the

tops of these ridges are knocked off with a hoe or board, leaving them smooth and flat. The plants are given a distance of 12 inches in the drill. Of course great care is used to make every plant live, as a uniform growth is essential if a uniform crop is to be harvested. Two or three days after the first setting the field is gone over, putting fresh plants wherever one of the original setting seems to be drooping or dying.

The cultivation is the same as that given the Cuban variety, and it must be rapid and shallow. The ground should be stirred at least once each week until the plants begin to bud, at which time cultivation should stop. It is very essential that the plants should have a continuous, rapid growth from beginning to maturity; they are often given a second application of fertilizer. For this cotton-seed meal or cotton-seed-hull ashes are usually applied when the plants are 12 or 14 inches high. This fertilizer will be available when most needed by the plant, furnishing as it does food for the many feeders or surface roots.

The same means used for keeping the worms off the Cuban crop are also used in the case of the Sumatra; and as the principal value of the Sumatra plant is its wrapper leaves, great care is exercised to preserve the soundness of the leaf. The Sumatra tobacco is topped higher than the Cuban; that is, only the seed bud is taken out, and all of the leaves are allowed to grow. If the land is exceedingly rich it is found best not to top at all, but to allow the plants to go to bloom. To top in that case causes the leaves to thicken and curl. It has been found by experience that Sumatra tobacco should be harvested at an early stage of ripeness, as the leaves will cure lighter and be more elastic; that is it will have more life. It is usual to take four to six leaves at each priming, thus going over the field four or five times before the whole crop is harvested. The methods and means of transporting this tobacco to the curing shed are the same as employed in transporting the Cuban variety, and the work in the barn or curing shed is also the same. The first priming, which means the first four leaves taken from the stalk, also the last priming, which means the last four or six leaves taken from the top of the stalk, are kept separate. Thus there are three grades, as follows: Bottom leaves, middle leaves, and top leaves.

When the tobacco is sufficiently cured it is packed in paper bundles, the same as described under Cuban tobacco, and delivered to the packing houses, each bundle being marked so that its contents can be known.

NEW *v.* OLD LAND.

As stated in the beginning of this article, new, low hammock land is necessary, or has been so considered. Some excellent Sumatra has been grown on old land, but this is decidedly the exception and not the rule. However, in 1896, as an experiment, a New York company operating in Gadsden County, Fla., built a shed over 1 acre of old land.

FIG. 1.—SUMATRA TOBACCO LEFT TO MATURE FOR SEED.

This also illustrates the development in the modern method of securing fine wrappers when not grown under canvas and where a fine, thin Sumatra wrapper is desired.

FIG. 2.—THE METHOD OF STRINGING THE LEAVES AND HANGING IN THE SHED.

The shed or arbor was 9 feet high and covered with laths, giving only half cover; that is, the laths were 2 inches wide and were placed 2 inches apart, so that there was half sunshine and half shade. This acre was made very rich and Sumatra tobacco was planted. The result was all that could have been hoped for, as they harvested a finer crop than had ever before been raised on the finest hammock land. In 1897 they increased their experiment to 5 acres, the result being as good as in 1896. In the following year, 1898, this concern planted more than 200 acres on old land, under shade, harvesting about 800 pounds per acre; and they claim that at least 50 per cent was wrapper. I have examined these tobaccos and I am sure that the island of Sumatra has never produced a finer type of wrapper leaf; and, what is more, this tobacco is just as acceptable to the trade as the finest imported Sumatra. All the farmers who are able to do so are building shades, and I think there will be at least 600 acres planted under shade in Gadsden County this year.

FERMENTING, GRADING, SORTING, AND BALING FLORIDA-GROWN CUBAN TOBACCO.

When the tobacco is first received from the curing shed it should be divided into the following grades: Medium to light leaves, medium to dark leaves, and fillers, making three sizes to each grade. It should then be tied in hands, about fifty leaves to the hand. This assortment is made to give each grade of tobacco such curing in bulk as it may need. As soon as the tobacco is tied in hands, proceed to bulk it. The light, thin tobacco, which needs but little curing, is put in small bulks of from 3,000 to 5,000 pounds; the medium to dark tobacco is put in bulks of from 8,000 to 10,000 pounds, as more curing is required for the dark tobacco. The fillers should be put in bulks of from 10,000 to 15,000 pounds, as they need thorough curing, and the larger the bulk the more intense is the heat. Allow these bulks to remain from six to eight days, according to the condition of the tobacco when bulked, then proceed to rebulk in the following manner: Six or eight cases should be filled with tobacco taken from the top of the bulk and then set to one side. Then take tobacco from the old bulk and lay the foundation of the new, continuing until the bulk is about half removed. Take the tobacco from the six cases first removed from the top of the bulk and put on the new; refill these six cases with the tobacco from the center of the old bulk, again setting these to one side; proceed to take the remainder of the old bulk and put on the new until the old bulk is entirely removed; then take the six cases that were taken from the center of the old bulk and put this tobacco on top of the new. Thus the top and bottom of the old bulk have become the center of the new one. The outside layers are also put in the center of the new bulk, and the center layers of the old bulk become the outer layers of the

new. These bulks are made about 6 feet wide and 12 feet long, the length and width being governed by the quantity to be bulked. In all cases the length and width of the bulk should be so arranged that when finished it will be at least 6 feet high.

After the bulk has been once repiled allow it to remain about ten days, when the same process of rebulking should be repeated. The second time the tobacco is rebulked it should be allowed to remain about fifteen days, and if the tobacco had sufficient moisture in the beginning the wrappers at the end of that time should be sufficiently cured to assort and bale. The fillers and low grades of wrapper can not be entirely cured with the moisture the tobacco had when received from the curing shed. These grades are allowed to remain in bulk until they are thoroughly dried out, and they are then given moisture by dipping them into water. If the tobacco is flimsy and has but little gum, a preparation should be made of stem juice. This is done by boiling Havana stems and pressing them well, making the juice quite thick, then adding 1 bucket of juice and about 1 gallon of sour wine to a tub of water. Dip the heads of the tobacco about 4 inches into the water and shake well, thus distributing the water through the leaves. The tobacco should then be lightly laid into cases and allowed to remain for about twenty-four hours, by which time the moisture will have been taken up and the tobacco become uniformly soft. Then proceed to bulk as before, keeping a close watch and rebulking from time to time as the tobacco may need, until it is thoroughly cured.

The above-described work should be done in a room prepared for this purpose called the sweat room. Steam pipes should run through this room, the pipes being so arranged that the room can be filled with steam whenever desired. The mean temperature of the room should be about 75°. When filling the room with steam all tobacco should be covered with blankets. The steam is not used to soften the tobacco, but to prevent it from drying out, which it will do if the air is allowed to get warm and dry. The temperature given above should be kept throughout the entire building, as it is desirable to keep the tobacco in about the same atmosphere; that is, the tobacco should never be taken from a warm room to a cold one while in the process of manipulation.

The best grades, of course, should always receive attention first. As soon as sufficiently cured, proceed to assort and classify, making the following grades: Light, medium-colored, and dark wrappers; light, medium-colored, and dark seconds. Make four lengths of each grade as follows: 12, 14, 16, and 18 inches. The first three grades represent the perfect leaves, the next three grades the imperfect, uneven-colored leaves. In making these assortments measured tills should be provided to receive each grade; each till being marked to show just what grade it contains, thus avoiding the possibility of mixing the various grades. With a force of about fifty women assorting, one inspector for each grade is necessary; that is, there should be one man who thoroughly

nderstands the classifying of tobacco to receive the light wrappers nd to go through them carefully and see that no leaves are put in that lo not rightly belong there. Each grade should be inspected in like nanner, after which it is handed over to the foreman of the tiers. It is hen tied into hands, thirty-five to forty leaves constituting a hand, nd packed carefully into cases, great care being taken to keep the eaves even and smooth. The foreman should put a ticket on each case o show its contents. The tobacco remains in these cases for three or our days, by which time the moisture in the leaf becomes uniform. Then give the tobacco to the "carrot" makers, who will make it into what is called Cuban carrots; that is, four hands are tied together, the heads being evened and the tobacco wrapped from head to tip with Cuban bast. Care should be taken to have the outside leaves very smooth, thus making a neat bundle of tobacco which weighs from 1 to 1¼ pounds, according to the size of the leaf, thickness, etc. As soon as the carrots are made proceed to put them in bales, eighty carrots constituting a bale, the material used being the same as is used in Cuba (fig. 1). When the package or bale is complete, it is identical in appearance with those put up in Havana. (See Pls. V, VI, VII.)

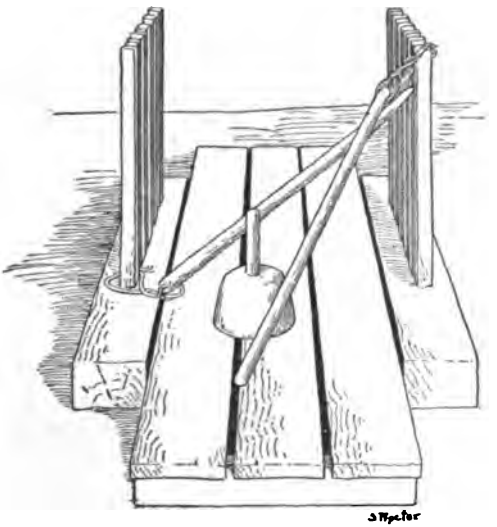


FIG. 1.—The Cuban press or baling frame with the sticks and mallet used in the process.

As stated in the beginning of this article, the tobacco is divided into three grades when it is first received into the packing house. The first handled is, of course, the grade from which the light wrappers are to be made. In this final selection there will be a lot of low-grade goods which must be used for fillers, and of course these will not be sufficiently cured for baling. So the low grade, or filler goods, are tied in hands and bulked down for further curing. In making this bulk the tobacco should be "petuned," if necessary.

The following preparation is used as a petuning solution by the best packers: To make a mixture of 5 gallons, use 2 gallons of New England rum, 1 gallon of sour wine, one-half pint tincture valerian, 1 ounce of oil of anise seed, one-half gallon black coffee, 1 ounce pulverized cloves, 1 ounce pulverized cinnamon, 2 pounds licorice paste dissolved in water, and sufficient water to make up 5 gallons. Mix this well and allow it

to remain for 24 hours. As the filler tobacco is bulked each layer should be sprayed with this preparation, using a fine atomizer for the purpose. This should be done with great care, as the idea is simply to give the tobacco a rich aroma, such as is found in the best Cuban goods.

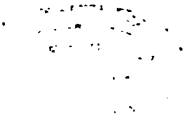
These bulks are turned or rebulked from time to time as may be required. When the tobacco is sufficiently cured and aged it is made up into Cuban carrots and baled. At this stage the odor of the petune used may be noticeable, but after the tobacco has remained in the bale for two or three months it can not be detected. The tobacco will have a rich aroma similar to the imported Cuban tobacco. The upper grades, that is the wrappers, should in no case be petuned, only the fillers or low grades being so treated.

All trashy, flimsy tobacco should be thrown out, and only the good, clean leaves put in carrots. The badly torn and trashy tobacco should be put through a hard sweat. These goods should be petuned liberally, thoroughly cured, and stemmed; that is, the stem should be taken out, leaving about 2 inches of stem at the tip of the leaf. The leaves should then be carefully smoothed out and put into pads, called by the trade "book *d* fillers." These are placed on screens and allowed to become quite dry. They are then taken up and put in cases, care being taken to keep the pads straight and all the tips of the leaves pointing in the same direction. As this tobacco is placed in the case it should again be petuned, using a fine atomizer and lightly blowing each layer. The tobacco remains in these cases three or four days, by which time the petune will be thoroughly taken up by the tobacco. Then the tobacco should be baled. In baling great care should be used to keep the pads straight, and the tips of the leaves should point to the center of the bale. In making "book *d* fillers" many scraps or small pieces of leaves—too small to put in the "book *d*" goods—will accumulate. These scraps, or picadura, as they are called by the trade should be thoroughly cleaned, picking out all stems and shaking the scraps in a coarse sieve, thus getting out all sand, etc. Spread out and allow the scraps to become dry, after which pack them up in cases petuning with the same care as with the "book *d* fillers." Allow them to remain in the cases two or three days and then bale.

As to the care of the tobacco after it is baled, that depends on the condition of the weather and the nature of the tobacco. The bale containing wrappers should be stored in a cool place, so that fermentation will cease. The bale should be stood on one end for the first two or three weeks after baling, reversing it about three times each week. After that time the bales may be laid flat and stacked three or four deep, reversing this position at least once each week until the tobacco has become well aged and dried out. After this, only a general care is necessary. The low grades, when it is desired that some fermentation should go on even after the tobacco is baled, should be stored in a close warm room and stacked about four bales deep. The position of the

FIG. 1.—EXTERIOR VIEW OF A CURING AND PACKING HOUSE.
The fermentation is done in the basement, and the sorting and packing on the first floor

FIG. 2.—ASSORTING AND CLASSIFYING TOBACCO ON THE FIRST FLOOR OF THE PACKING HOUSE.



bales should also be reversed at least once a week until fermentation stops. The wrapper grade should be ready for use after being in the bale three months, while the fillers should remain in bales at least six months.

THE MANIPULATION AND PACKING OF SUMATRA TOBACCO.

When the tobacco is received from the plantation, it should immediately be taken from the package and divided into three grades, as follows: Light thin leaves; medium-weight leaves of medium color; and dark heavy leaves. Then it should be tied into small bundles of about 50 leaves to a bundle and put in bulks of from 3,000 to 5,000 pounds each. This division is made in order to give to each grade just the amount of curing needed. Keep the room in which these bulks are made at a temperature of 75°. This is done by means of steam pipes running through the building. Also have the pipes so arranged that the room can be filled with steam, thus making the air soft and moist. These bulks are to be watched, turned, and rebulked from time to time in the same manner as Cuban tobacco. There are no fixed rules by which this work can be done, as the condition and type of tobacco govern the work in all cases. Every effort should be made to sweat this tobacco to a finish with what moisture it has when received from the curing shed. This can be accomplished if the tobacco is delivered from the farm in a proper condition. This is especially true if the tobacco is light and thin, as but little heat is needed to finish its curing; but if the tobacco is heavy and gummy, it inevitably becomes necessary to use water to force the curing.

It is the experience of the packers that there is nothing more suicidal than to offer to the trade raw, uncured tobacco. It must be cured even at the expense of color, etc. Light tobacco is made in the field, not in the curing shed or packing house. Thin light tobacco will cure out thin and light. Heavy, gummy tobacco, though light in color when taken from the poles or curing shed, will be dark when sufficiently cured for use. It is often the case that tobacco which is thin, light, and very fine is delivered to the packer from the farm in an exceedingly dry condition. This tobacco must be softened; but to give it water is risky, whether the water is applied by dipping or by spraying. Even in using a very fine atomizer it will get water stains. The following method is therefore adopted:

After softening up a lot of low-grade goods pile in a great heap, and allow it to remain until it becomes very hot. Take this hot tobacco and make a bed about 5 feet wide, 10 feet long, and 1 foot thick; then lay a strip of paper about 12 inches wide across the end of the pile and begin bulking the dry tobacco. Allow the body of the leaves to lie on the paper and the head of the hand to rest on the hot tobacco, running rows across the bulk. Begin again, allowing the next layer to rest on the first with the heads of the hands pulled a little forward,

resting on the hot or wet tobacco. This is continued the entire length of the bulk. Then reverse the order, allowing the heads of the hands to point up, dropping each layer back so that about 5 inches of the head will show. This is continued until the full length of the bulk has been covered, leaving nothing exposed on the top but the heads of the hands, all tips and bodies of the leaves being in the center. Put on another thick layer of wet tobacco and the strip of paper, and bulk again as before. Continue this until the bulk reaches the height of 5 or 6 feet; then cover well with low-grade stuff and allow the bulk to remain five or six days, by which time the dry tobacco will have taken up sufficient moisture and heat from the wet tobacco to be ready for the assorters. In this way the possibility of water stains is avoided and the tobacco comes out soft and clean.

Proceed to assort in the following grades, making four sizes each: Light plain wrappers, light spotted wrappers, medium-colored plain wrappers, medium-colored spotted wrappers, dark plain wrappers, and dark spotted wrappers. Make the same number of grades in seconds. The seconds are leaves slightly broken and uneven in color. Thus we have twelve assortments of wrappers of four sizes each; in all, forty-eight grades. As in the handling of Cuban tobacco, there should be an inspector for each of these assortments, who will take great care that a proper assortment is made. The tobacco is then given to the foreman of the tiers, who has it tied in hands, putting thirty-five to forty leaves in each hand. It is again put in bulk, packing fan shaped—that is, the leaves when tied are folded once and the hand is carefully flattened. The bulks are narrow and so arranged that the tobacco will slowly age and dry out. When sufficiently dry, it is packed in matting just as is done in Sumatra. After finishing the wrapper grade take up the filler portion, giving it the same treatment as is given the Cuban tobacco, putting the sound leaves in carrots and stemming the lower grade for "book *d* fillers." With this the work of the packer ends and the work of the salesman is in order (Pl. VIII, fig. 2).

DEVELOPMENT OF THE TOBACCO INDUSTRY IN FLORIDA.

The cultivation of tobacco in Florida is not a new industry, but an old one revived. Far back in the forties and fifties Gadsden County became famous for the fine wrapper leaf produced there. The industry thrived until the civil war, but from that time until 1888 the production of tobacco in Florida was so small that it attracted but little attention. In 1880 only about 90 acres were grown in the State; in 1890 the acreage had increased to more than 1,000 acres; and in 1898 there were at least 8,000 acres, giving a yield of 4,000,000 pounds. After the close of the war a few farmers continued to grow tobacco in a very small way, and they would often accumulate three or four crops before finding a buyer, and even then the price would be low. The farmers became

FIG. 1.—PUTTING UP THE CUBAN TOBACCO INTO CARROTS.

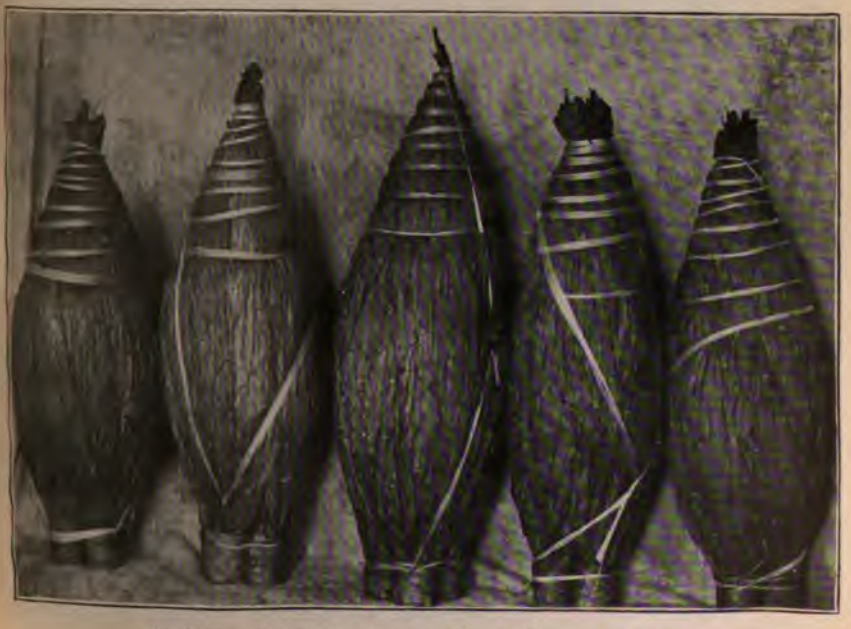
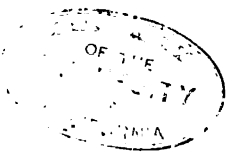


FIG. 2.—SAMPLES OF 12, 14, AND 16 INCH CARROTS READY TO BE BALED.



discouraged and reduced their acreage, until, as before stated, in 1880 there was less than 100 acres planted in tobacco in the entire State.

"OLD FLORIDA" TOBACCO.

The variety of tobacco grown in Florida before the civil war, and especially famous for its beautifully spotted wrappers, was known simply as Florida tobacco, being unlike any type produced in any other part of the country. When the industry was revived in 1889 and 1890, many of the old planters had seed of what was known as "Old Florida," which they again planted. But the style had changed; Sumatra, with its bright rich gloss, had established itself; "Old Florida" proved to be a back number and the farmers had to give it up. In the year 1884–85 several farmers of small plantations obtained seed from the island of Cuba and a number of small patches of it were grown. It was this tobacco that revived the industry. Some of the tobacco grown from the Cuban seed fell into the hands of a large cigar-manufacturing concern of New York, which made it into cigars. The quality of these cigars proved so satisfactory, that men were at once sent to Florida to study further the possibility of producing a tobacco that would meet the requirements of the trade. After going over the old tobacco sections of the State they became confident that the attempt could be made a success, and they purchased and equipped plantations in Gadsden County. This concern was followed by several other companies, all of which now own and operate large farms, each having established large and well-equipped packing houses in or near Quincy, the county seat of Gadsden County. These firms, in addition to the tobacco they grow, also buy extensively from local farmers.

EXPERIMENTS IN IMPROVING TOBACCO.

In order to improve the tobacco and adapt it to the trade demands, these concerns have indulged in all sorts of experiments, some of which have proved quite expensive. However, they have met with such a degree of success as to warrant them in continuing the experimental work. There were many questions to be settled. First of all, what seed should be used. To settle this question seed was obtained and tried from every part of the country. This point, however, was soon determined and now there are only two varieties grown in the State—Sumatra and Cuban—the Sumatra giving the style required for the wrapper and the Cuban giving the filler qualities nearest the requirements of the trade. As each of these tobaccos possesses the quality and style needed, the kind of soil best suited to each was the next point to be settled; then the proper fertilizer, the quantity necessary, and the proper cultivation had to be found out by numerous experiments. At first it was thought that but little fertilizer of any kind should be used. The tobacco was set out early, given a distance

in the drill of about 24 inches, and topped low; that is, not more than twelve or fourteen leaves were allowed to each stalk. The result was that the plants produced large, coarse, undesirable leaves. The next step was to give the tobacco less distance in the drill; 18 inches were tried. The result was better, but not satisfactory. From time to time changes were made until now the plant is given 14 inches, the fertilizer is doubled, and the tobacco is topped higher, allowing at least sixteen leaves to each stalk. The result is that the leaves are of the desirable size and finer in quality and appearance.

For a long time the cultivation was continued until the time of harvesting, but this was decidedly wrong. The writer has seen fields of tobacco plowed that were ripe and ready to be harvested, and in consequence the tobacco turned green and started a new growth. This generally increases the yield, but almost totally destroys the quality of the tobacco. At present the cultivation stops as soon as the plants are topped.

When the Sumatra seed was first introduced into Florida, the land selected, the amount of fertilizers used, and the methods of cultivation and harvesting employed were the same as those practiced in growing the Cuban variety. With this treatment Sumatra proved to be an absolute failure; many abandoned the seed, while others continued to experiment. It was soon found that the soil had to be exceedingly rich, the growth quick; that low topping was ruinous, and that each stalk should have from twenty-four to thirty leaves, according to the strength of the soil. When the land was exceedingly rich it was found best not to top at all, but to allow the plants to go to bloom. Then the leaves would be of desirable size, thin and smooth; whereas if topped, the leaves would curl and thicken. This tobacco is also crowded into the drill, the plants being given only from twelve to fourteen inches. The growth is rapid; the top leaves soon serve as a shade for the middle and lower leaves, and the results have been most gratifying. New land proved to be more desirable for this variety of tobacco, and it was noticed that when trees were left standing in the field the plants shaded by trees were far superior to the plants not so shaded. From this the idea of building artificial shade had its birth. It was also found that no good results could be obtained if the plants were cut, but the leaves should be primed off just as they ripen, and at a very early stage of ripeness.

CHANGES IN METHODS AND IMPROVEMENT IN STYLE AND QUALITY.

If we consider the tobacco industry in Florida during the past ten years, we will find great changes in the methods and improvements in the style and quality of the tobacco produced. Why were these changes in methods made? Because certain manufacturers knew just what the trade required. After the crop was harvested and cured they were able to discover its faults or good points, and if faults were found,

FIG. 1.—MAKING UP A BALE OF CUBAN TOBACCO.

FIG. 2.—THE CUBAN BALE WITH AND WITHOUT THE CANVAS COVER.

they studied how to remedy them; if good points were observed, they studied to find how they were obtained. Each year there were a number of small experimental plots on which different kinds of soil were tested, different fertilizers used, and different methods of cultivation employed. The tobacco of each plot was harvested at different stages of growth—ripe, overripe, and underripe. In the curing shed this experiment was continued. If there were four experimental crops, they were cured in four different barns and a part of the tobacco from each plot put in each barn.

For convenience, we will call the four plots A, B, C, and D and the barns or curing sheds 1, 2, 3, and 4. In each barn we have tobacco from the four plots, and each barn receives different manipulation. The tobacco from each barn was marked so that it could be easily identified, and when thoroughly cured its quality was tested. It can be seen at once that such a method of experimenting is practicable. We will say that all of the tobacco in barn No. 2 made the best showing and that the tobacco from plot A was the most desirable. Therefore we would naturally assume that the soil, fertilizer, and method of cultivation of plot A was the best and the management of barn No. 2 was the nearest correct. We could also determine at what stage of ripeness the tobacco should be harvested in order to obtain the best results. This final test can not be made, however, until the tobacco has been carried through the process of fermentation and all the qualities of the leaf thoroughly developed.

COST OF GROWING TOBACCO IN FLORIDA.

The following figures will undoubtedly surprise many not acquainted with the growing of tobacco in Florida. The cost per pound of the tobacco produced will seem exceedingly high. However, the figures are in every way conservative, and the experience of the large growers of tobacco in Florida will not disprove their correctness. In the first place, in order to grow 100 acres of tobacco each year it is necessary to have a farm containing at least 500 acres, as it is not considered desirable to plant the same field in tobacco for more than two or three consecutive years. These lands should be planted in other crops or allowed to rest for three or four years; so every two or three years the locality of the tobacco fields should be changed. On this point all farmers (I mean successful farmers) do not agree. Still, it is the opinion and practice of a majority of the successful farmers to rotate their crops, tobacco being the main crop for which the plantation is equipped. The fields planted in tobacco should be followed by such other crop as will tend to improve rather than to impoverish the land. Usually corn is planted, and when giving the corn the last plowing the field is sown in cowpeas. The writer has known fields to be greatly improved by the planting of these crops where no fertilizers were used. As soon as the corn is harvested and the pea vines begin to die they should be

plowed under. After this has been done for two or three years the field is again ready for tobacco, and it has really gained in general fertility.

While it is the special purpose of the farm to grow tobacco, any concern operating such a farm will strive to produce corn, oats, hay, and all such produce as may be necessary to sustain the farm. The first thing is to carefully select the lands best suited for tobacco and to plant on these lands only such crops as will tend to improve the soil. Potatoes, sugar cane and the like should never be raised on tobacco lands, as they are very exhausting to the soil. Many farmers, as soon as they locate the lands on which they expect to grow tobacco, sow such fields in beggar weed and cockleburs, and as soon as a good growth of either of these weeds can be obtained it is plowed under. This tends to improve the land.

In the following figures it will be noted that no credit is given the farm for any other crop than tobacco, all cost being applied to the tobacco crop, because whatever else is grown is simply used to sustain the farm and assist in producing the tobacco. Feed for stock is charged against the first crop—January to June, six months—by which time the farm should have produced oats, millet, and such other forage as may be necessary to feed the stock.

Cost of farm and buildings.

500 acres of land	$5,000.00	
House for superintendent	500.00	
House for assistant superintendent	250.00	
20 tenement houses or cabins	1,000.00	
10 barns, 36 by 96 feet	5,818.50	
160,000 laths	320.00	
Stables, cribs, and other outhouses	500.00	
Total cost of land and improvements		$13,388.50

Stock and implements.

8 mules, at $120 each	960.00	
1 horse for superintendent	125.00	
Wagons, harnesses, and implements	500.00	
Total cost of stock and implements		1,585.00
Total		14,973.50

Labor and general expenses.

Superintendent, for twelve months	900.00
Assistant superintendent, twelve months	480.00
2 foremen, for twelve months	360.00
10 men laborers, for twelve months	1,560.00
15 men laborers, for six months	1,170.00
25 women, for six months	1,200.00
Feed for stock for six months	270.00

FIG. 1.—THE SAMPSON JACK-PRESS USED FOR MAKING THE SUMATRA BALE.

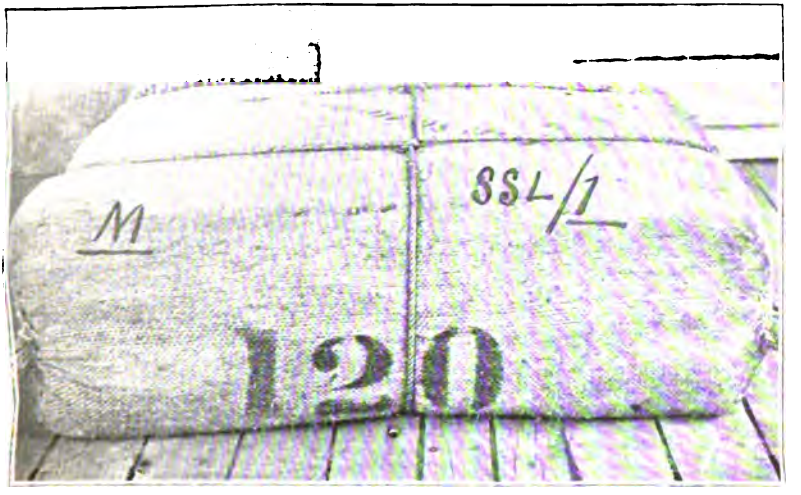


FIG. 2.—A FINISHED SUMATRA BALE OF FLORIDA-GROWN TOBACCO.

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CALIFORNIA

Labor and general expenses—Continued.

50 tons of cotton-seed meal	1,050.00
10,000 bushels of cotton seed	1,500.00
Incidental expenses	150.00
Total amount of general expenses	8,640.00
Interest on $8,640 for six months	259.20
Interest on $14,973.50 for twelve months	898.41
10 per cent depreciation on land and improvements	1,338.85
20 per cent depreciation on stock and implements	317.00
Amount chargeable to tobacco crops	11,453.46

Total amount of tobacco produced, 60,000 pounds.
Average cost about 18½ cents per pound.

KIND OF BARN DESIRED AND ITS COST.

In the development of the tobacco industry in Florida one of the important points to be determined was, what kind of a barn or curing shed was most desirable. Different kinds of buildings were constructed—some broad and flat, others narrow and tall; some with wooden shutters, other with glass windows. The man in favor of the glass windows thought that to cure tobacco light in color, much light was necessary. This proved a failure, as light tobacco is grown and not made in the curing shed. The man with the tall, narrow barn thought

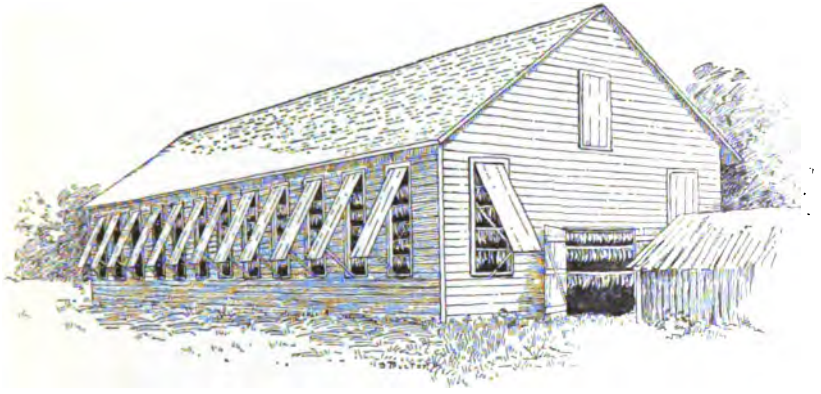

FIG. 2.—Shed filled with primed leaves with the ventilators open.

that to cure tobacco quickly was the proper thing; so he constructed his barn in such a way as to make it as hot as possible, in order to cure the tobacco quickly. The result was "house burn," bad color, and dead tobacco. The man with the broad, flat barn wanted slow curing. This style of barn proved nearest to the proper barn. However, the idea of building a barn for slow curing was carried too far, the result being that the tobacco molded because of insufficient heat and ventilation. The barn illustrated in figs. 2–6 has been adopted by the most successful growers as the correct barn.

ESTIMATES AND COST OF CONSTRUCTION OF BARN.

The following detailed estimates of the cost and quantity of material necessary for the construction of such a barn, together with the cost of labor, may be of interest:

Estimate of material required for tobacco barn.

	Feet.		
Sills, 22 pieces 6″ x 6″ x 20′	1,320		
Studding (24-inch centers), 160 pieces 2″ x 4″ x 18′	1,920		
Plates, 14 pieces 2″ x 6″ x 20′	280		
Rafters (26-inch centers), 88 pieces 3″ x 6″ x 24′	3,168		
Strongback for rafters, 6 pieces 3″ x 6″ x 32′	288		
Strongback supports, 14 pieces 3″ x 6″ x 8′	168		
Uprights for tiers, 10 pieces 4″ x 4″ x 21′	280		
Uprights for tiers, 10 pieces 4″ x 4″ x 24′	320		
Uprights for tiers, 10 pieces 4″ x 4″ x 27′	360		
Uprights for tiers, 10 pieces 4″ x 4″ x 30′	400		
Tier poles, 240 pieces 2″ x 4′ x 16′	2,560		
Ribbons, 56 pieces 1″ x 4″ x 20′	374		
Cross braces, 14 pieces 1″ x 6″ x 25′	175		
Ventilators, 16 pieces 1″ x 12″ x 12′	192		
Ventilators, 32 pieces 1″ x 12″ x 10′	320		
Sheathing for roof, 2,750 feet 1″ x 3″ x any	2,750		
Weatherboarding, 4,500 feet 1″ x 6″ x any	4,500		
Doors and shutters, 1,000 feet G. and T. ceiling	1,000		
	20,375, at $10		$203.75
Pillars, 2,000 brick, at $10			20.00
Pillars, 2 barrels stone lime, at $1.50			3.00
Shingles (6-inch to weather), 30,000 4″ x 18″ cypress, at $3			90.00
Ventilators, 60 pairs 8 inch T hinges, at 12½ cents			7.50
Shutters, 22 pairs 8-inch strap hinges, at 15 cents			3.30
Doors, 8 pairs 12-inch strap hinges, at 20 cents			1.60
Shutter props, 11 pairs 6-inch T hinges, at 10 cents			1.10
Ventilator levers, 24 angle brackets, at 10 cents			2.40
Intermediate tiers for primed tobacco:			
5,200 feet barn wire			5.00
20 pounds staples			1.00
2 kegs 4-penny cut nails, at $3			6.00
3 kegs 10-penny cut nails, at $2.50			7.50
2 kegs 20-penny cut nails, at $2.35			4.70
Labor			225.00
Total cost of barn (without paint)			581.85

Building, 36 x 96; 16 feet from sills to plate tiers, 4 tiers; 13 feet from plate tiers to point of roof, 2 tiers. All the tiers are 4 feet apart each way. When tobacco is primed the tiers are doubled in quantity. This is done by stretching heavy wire so as to alternate with the original tiers.

There are years when the seasons are very unfavorable when the cost will naturally be increased, while during other years when the seasons are exceedingly favorable the cost is reduced. It will be noticed that the barn room provided for this 100 acres of tobacco is small. The writer is aware of the fact that if the entire acreage of

bacco should ripen within one month the space would be altogether sufficient, but on such a farm harvesting should begin the middle of ne and continue until the 1st of September, so each barn would be

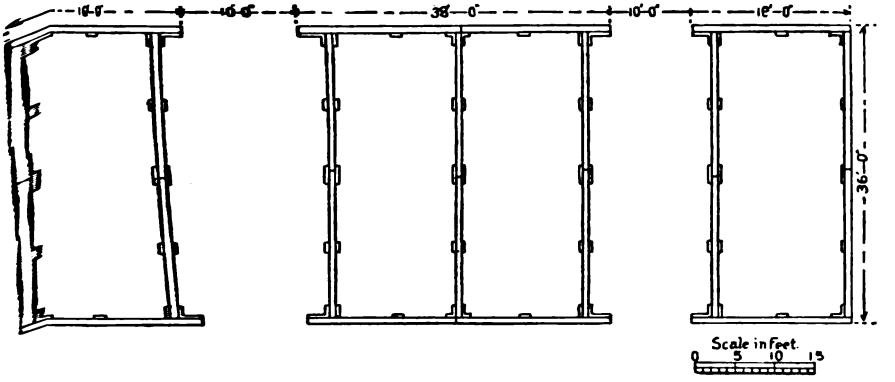

FIG. 3.—Ground plan of tobacco barn.

filled two or three times. In this way the barns would be quite sufficient.

TOBACCO GROWN BY THE FARMER COMPARED WITH THAT GROWN BY THE TOBACCO PLANTER.

If a farmer of a small tobacco farm is asked what it costs to raise tobacco in Florida, he will say from 10 to 12 cents per pound, according to the season. The explanation of this is, the farmer lays out his farm not for the sole purpose of growing tobacco, but for producing everything needful for the support of himself and family. Such a farmer may have in cultivation 100 acres, only 8 or 10 of which are in tobacco. His attention is given to producing corn, potatoes, peas, rice, and peanuts, and

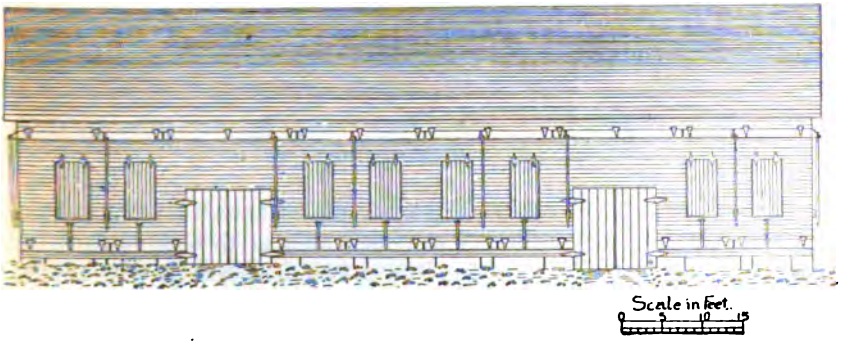

FIG. 4.—Side elevation of tobacco barn.

to the raising of hogs and cows—in fact, all things necessary for the sustenance of his family. As a money crop, he plants 10 acres in tobacco, against which he makes no charge for his own services or for

the services of any member of his family who may assist in its produ tion. He simply counts the fertilizers used and the actual time l hired labor worked in the field; so with this method of calculation t actual cost of producing tobacco by anyone engaged in tobacco raisi as a business would be greatly at variance with the figures given by farmer.

The question then naturally arises, if the farmers can raise tobac at 12 cents per pound and it costs the larger concerns from 18 to cents per pound, why would it not be better for the large concerns

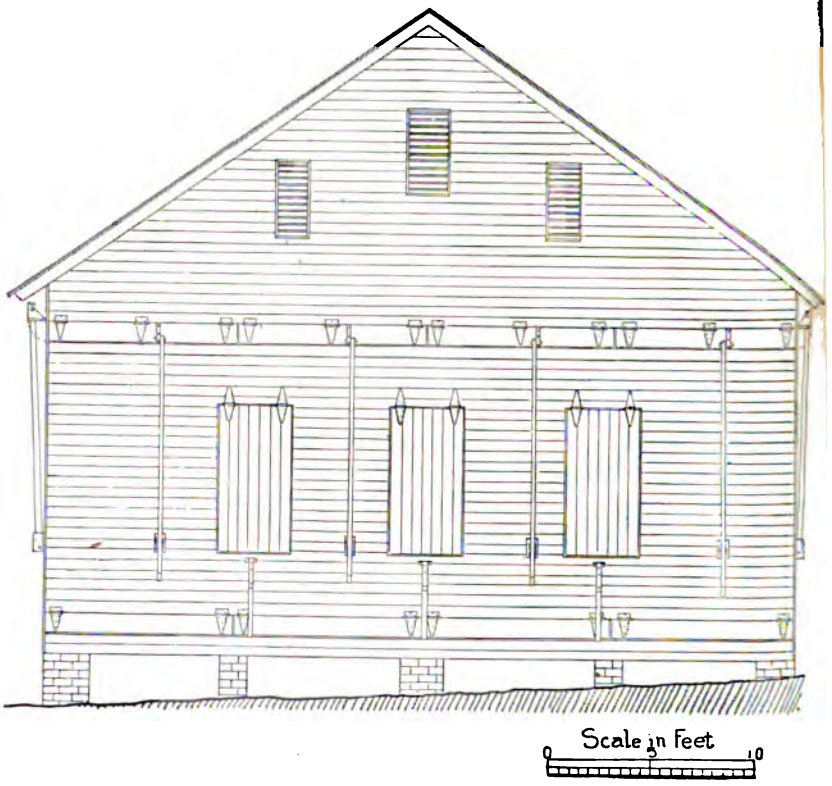

FIG. 5.—End elevation of tobacco barn.

let the farmers grow all the tobacco and buy of them? The answer is this: The large concern that has sufficient capital to equip a farm and grow 100 acres of tobacco is also able to employ good men to manage the farm—men who give their entire time and attention to the growing and curing of the tobacco. This care begins with the first work on the farm and does not end until the tobacco is delivered to the packing houses, the tobacco receiving at all times the greatest care and attention. The superintendent and his assistant watch and study the tobacco closely and do all things necessary for its perfect development.

These large farms are owned by leaf dealers who have been long in the business, who know just what the trade wants, and who bend all their energies to secure it. There is no time at which the tobacco is neglected. The farmer with a small plantation may produce in the field fully as good a crop as is raised by the larger concern, but after the tobacco is taken from the stalks this farmer simply packs it in boxes of all sizes and kinds, places it in an open barn, and apparently forgets that he has any tobacco; that is, if one is to judge from the care and attention it receives. This is the weak point on the small

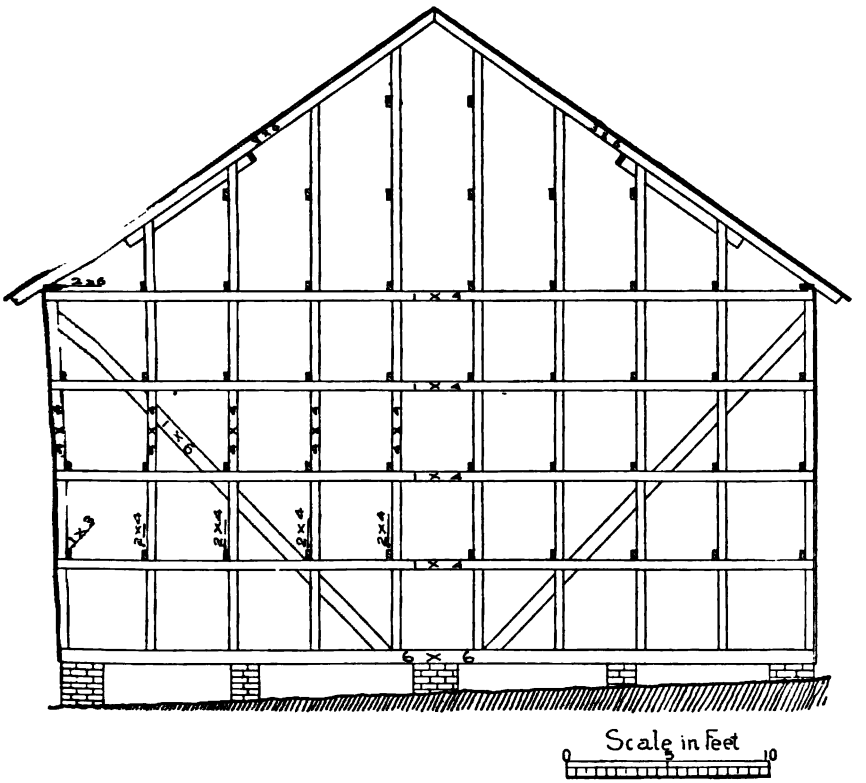

FIG. 6.—Middle section of tobacco barn.

tobacco farms, and success can never be attained until this point is remedied. A poor crop in the field must inevitably produce a poor finished article, although the tobacco may be improved or injured by proper or improper treatment after curing. A fine crop in the field is no guaranty that it will be fine and desirable when the buyer comes around, since in the absence of proper care it will become exceedingly poor and, in some cases, almost worthless. Of course, there are some farmers of small tobacco plantations who recognize these facts and who produce and market just as good tobacco each year as do the larger

growers, but they are the exception rather than the rule. Such men make a study of tobacco, and from them the larger growers obtain each year good and valuable points. The dealer who wishes to succeed becomes a farmer; he knows that while it may cost him more to produce the tobacco than to buy it from the small farms, it will be more profitable in the end, as he will then have what the market demands.

As has been previously stated, the manipulation of the barn is entirely governed by weather conditions. This much, at least, can be said—the barn should be so managed as to have the tobacco go in and out of case once in every twenty-four hours, care being taken not to allow the tobacco to become too damp or too dry. When this is done with care, the tobacco that is hung on the stalks will cure in about thirty days; that which is primed and strung will cure in about fifteen days. The present method of manipulating these tobaccos after they are pole-cured is quite different from what it was years ago. Then they simply took the tobacco from the poles, made it into three assortments—long wrappers, short wrappers, and fillers—and packed them into boxes, where they remained until a buyer came. When sold, the buyer had the case well closed and shipped just as it was. If the tobacco happened to sweat and cure out well in the case, all well and good; but if not, it did not seem to occur to the growers that any thing could have been done to insure good curing. To reach the present methods many expensive experiments were made. At first it was thought that only a slight curing was necessary, and the tobacco was baled raw. The trade found fault with this because the tobacco was rank. Then the fillers were thoroughly cured and all went well, the light wrapper—or so-called light wrapper—still being cured but little, as thorough curing would so darken the leaf that it could not pass for light. The result was that the Florida wrappers were condemned by the trade. The packers of Florida to-day will not offer to the trade tobacco that is not thoroughly cured. The outcome is that Florida wrappers are in demand at present, and the fillers from the Cuban seed bring the highest price of any filler tobacco produced in the United States. This is largely due to the methods of fermentation, as well as to the methods of cultivation.

The values of these different grades vary so greatly that any figures given would be merely conjectural, as the first wrappers will be valued at from $1 to $2.50, the seconds from 40 to 75 cents per pound, and the fillers from 30 to 45 cents per pound, so exact figures can not be given. Of course these prices refer to the tobacco baled and ready for the manufacturer. The prices paid the local farmers vary from 12 to 40 cents, according to the style and quality of the crop. Some years the farmers have lost money, while other years they have realized good prices and made fine profits. As a whole the farms of Gadsden County are in good condition and the farmers are prospering.

As already shown, the tobacco will cost the large grower, del
at the packing houses, at least 18 cents per pound. This by no
ends the cost. The present methods of fermenting, assorting, cl
ing, and baling cost from 6 to 8 cents per pound, including
aterial, interest on money, insurance, etc. The tobacco will
shrinkage in this process of work of at least 10 per cent, an
the shrinkage will reach 20 per cent from the time of delivery
packing house to the time the tobacco is marketed, so that th
cost of the tobacco at the time of marketing can be estimated
om 30 to 32 cents per pound. The following is about the resul
erage Florida packing: Of a lot of 100,000 pounds there will be
per cent first wrappers, 35 per cent second wrappers, 40 per
ood clean fillers, and 15 per cent of trash and waste; or 10,000
f first wrappers, 35,000 pounds of second wrappers, 40,000 pou
ller, making in all 85,000 pounds, with a loss of 15,000 pounds
oint of interest now is, How can the per cent of upper-grade go
ncreased? This must be solved by continuous experiments alo
line from seed bed to bale.

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O. E. S. 328.

U. S. DEPARTMENT OF AGRICULTURE.

Report No. 63.

THE WORK OF THE AGRICULTURAL EXPERIME STATIONS ON TOBACCO.

Abstracted by J. I. SCHULTE, Office of Experiment Stations,

WITH INTRODUCTION AND COMMENTS BY

MILTON WHITNEY,

CHIEF, DIVISION OF SOILS.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1900.

RECENT PUBLICATIONS OF THE DEPARTMENT ON TOBA

Bulletin No. 11, Division of Soils.—Tobacco Soils of the United States, a P
inary Report upon the Soils of the Principal Tobacco Districts, by Milton Wh
Chief of Division of Soils.

Farmers' Bulletin No. 60.—Methods of Curing Tobacco (revised edition), by
Whitney, Chief of Division of Soils.

Farmers' Bulletin No. 82.—The Culture of Tobacco, by Otto Carl Butterwe

Farmers' Bulletin No. 83.—Tobacco Soils, by Milton Whitney, Chief of Di
of Soils.

Cultivation of Tobacco in Sumatra, by Emile Mulder.

Report No. 59.—Curing and Fermentation of Cigar-leaf Tobacco, by Dr.
Loew, of the Division of Vegetable Physiology and Pathology.

Report No. 60.—Temperature Changes in Fermenting Piles of Cigar-leaf To
by Milton Whitney and Thomas H. Means, of the Division of Soils.

Report No. 62.—Cultivation of Cigar-leaf Tobacco in Florida, by Marcus L.
of the Division of Soils, in cooperation with the Division of Vegetable Phys
and Pathology.

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
DIVISION OF SOILS,
Washington, D. C., January 6, 1900.

SIR: In taking up the line of tobacco investigation, authorized by the Fifty-fifth Congress, it was considered desirable to review the work done by the experiment stations. To this end Dr. A. C. True, Director of the Office of Experiment Stations, was requested to have an abstract made of all such work and he detailed Mr. J. I. Schulte of that office to compile this data.

As I believe the results of the experiment station work thus brought together will be of value to the stations in planning further, more systematic, and more comprehensive work, and as they will also be of interest to tobacco men, I recommend that the accompanying manuscript be published as Report No. 63 of this Department.

Respectfully,

MILTON WHITNEY,
Chief of Division,
In charge of Tobacco Investigation.

Hon. JAMES WILSON,
Secretary of Agriculture.

LETTER OF SUBMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
OFFICE OF EXPERIMENT STATIONS,
Washington, D. C., January 2, 1900.

SIR: In accordance with your request I send you herewith abstracts of the accounts of investigations on tobacco, which have been published by the agricultural experiment stations in the United States and Canada. These abstracts have been prepared by Mr. J. I. Schulte, of this Office, in accordance with my instructions. Only in a few States have the experiment stations undertaken tobacco investigations in any thorough manner. In many cases their studies on this subject have been incidental to other inquiries or have been distinctly minor pieces of work. This will very largely account for the fragmentary character of the work, as indicated in this summary.

Respectfully,

A. C. TRUE,
Director.

Prof. MILTON WHITNEY,
Chief of Division of Soils.

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THE WORK OF THE AGRICULTURAL EXPERIMENT STATIONS ON TOBACCO.

INTRODUCTION.

For some years past the agricultural experiment stations in various sections of the country have carried on investigations in the raising and curing of tobacco. This work for the most part has been desultory and, being published in so many bulletins—often as a small note or record of progress—it was considered advisable to bring the work together in order to show what lines had received attention and what results had been attained. It is hoped that by thus bringing together the lines of work and presenting the subject as a whole, some of the stations may be induced to take up the subject in a more comprehensive and thorough manner and throw more light upon the various phases of the growth and curing of tobacco which have assumed such a degree of economic importance in many districts of this country.

Some of the subjects which have been investigated by the stations have been fully worked out by growers in one or more sections of the country, and there are a number of problems which the growers have solved by themselves without the intervention or assistance of the stations. Then again there are many problems now confronting the tobacco growers which they have not been able to solve and which the experiment stations have not taken up, or at least have not published reports upon. So far as possible in the limits of this article, these subjects are briefly referred to, in order to make this report as full, comprehensive, and valuable as possible.

Tobacco, as a commercial crop, is at present confined to a very few of the States, and to limited and rather well-defined areas in those States. It thus happens that only a very few of the agricultural experiment stations are located in or near tobacco districts. The tobacco industry has become so highly specialized that it is necessary for the successful investigator to become closely identified with the economic details of tobacco culture and handling in order to both intelligently select material to work with and to plan the work for some real economic advancement. Under these conditions it would never be desirable for many stations to undertake investigations in

tobacco, but it would be very much better if the work could be centralized and undertaken in a systematic way by two or three stations favorably located for this work. It is well to realize this fact, as there is no question that the difficulties in the way of investigations along valuable economic lines are so very great and require so much technical skill in the manipulation of the leaf that it is considered very far from advisable for stations to undertake the work unless they are well equipped and favorably located.

Much of the work which has been done is of marked value. As will be seen from the table of contents, it has covered a great range of subjects. Nevertheless, it would be better for the stations to concentrate the work rather than for a great number of stations to undertake these particular lines.

METHODS OF GROWING PLANTS IN SEED BEDS.

Various methods of starting tobacco seed were compared at the Alabama State Station in 1892 and 1893.[1] Seed was started in open beds and in beds covered with cheese cloth. During the first year of the experiments the greater number of plants in the open beds were destroyed during a cold spell in March, and during the second season they were injured by the flea beetle. In the covered beds the plants came up well, grew rapidly, and were not subject to insect attacks. From the results obtained it is evident that under the climatic conditions of Alabama young tobacco plants are readily affected by low temperatures and quickly killed by freezing weather. The method of starting the seed in a covered bed was the most successful.

The Colorado Station[2] in pursuing this work in 1889 found that it took no longer to produce plants suitable for setting out by growing seeds in cold frames than by the use of the hotbed.

The following method of germinating tobacco seed proved perfectly successful at the Georgia Station in 1892.[3] Tobacco seed was placed in wine glasses and soaked in water for half an hour. The water was then poured off from the seed and the glasses placed in saucers containing water, and a tumbler inverted over each glass to confine the moistened seed in a damp atmosphere. The glasses were then placed in a warm room and the seed kept moist. About a week afterwards, when the seed began to sprout, it was sowed in a cold frame, and within four weeks from that time plants suitable for transplanting to the field were obtained.

Experiments in growing seedling plants were conducted at the Central Experimental Farm, Canada, in 1893 and 1897.[4] Seed was sown

[1] Alabama State Station Buls. Nos. 44 and 54.

[2] Colorada Station Bul. No. 10.

[3] Georgia Station Bul. No. 19.

[4] Canada Expt. Farm Rpts., 1893 and 1897.

in hotbeds, and some of the plants produced were transplanted to cold frames and hotbeds before they were set out in the field. In 1893 a striking difference was noticed between plants set out from the original hotbed and those transplanted to the cold frame prior to setting out. The plants taken to the field from the cold frame were stalkier, stronger, and grew more rapidly than those set out from the first seed bed, and they were not disturbed very much by being transplanted, but readily established themselves in their new location. The plants taken directly from the hotbed to the field were much slower in taking root and many of them had to be replaced.

In 1897 plants were transplanted to a second hotbed before setting them out in the field. The results showed that this practice gave stalkiness and vigor to the plants and materially reduced the number lost in transplanting to the field. This method is recommended for eastern Ontario and the Province of Quebec.

A vast amount of experience has of course been obtained in all of the tobacco districts in this practical matter of the seed bed. The old practice of growing plants in protected areas in the forest has been very generally superseded by using plant cloth for covering or by hotbed sash, or even by starting the plants in greenhouses.

In certain districts considerable trouble and loss have been experienced from certain fungous diseases. To prevent these, the soil used for the plant bed has been sterilized with boiling water, hot stones, or, preferably, with steam under high pressure. The method of steaming is quite feasible where there is a power plant from which steam can be obtained and is to be recommended where fungous diseases give any serious trouble in the plant bed.

Further investigations along this line are needed, both to ascertain to what extent injuries of this kind are felt and the cost of sterilizing the soil under the different methods which are used in horticultural work.

Further investigations are also needed in the line of protection against insects both above and below ground. Also investigations are necessary on methods of treating the plants and preparing them for the field. There are questions on the treatment of the plants in the seed bed, such as the matter of watering, which should be carefully considered; also the very important subject of the kind of soil best adapted—whether it should be mixed with manures and fertilizers, what kinds, and to what extent. The production of a vigorous, well-formed plant for setting out is a subject which deserves the most careful consideration.

The size, specific weight, and condition of ripeness of the seed, as well as the method of planting, have a very important bearing upon the crop, as horticulturists have shown with a number of crops.

VARIETIES OF TOBACCO.

At the North Louisiana Station[1] at Calhoun ten varieties of tobacco, namely, Conqueror, Hester, Long-leaf Gooch, Ragland Improved, Sweet Oronoko, White Burley, Comstock Spanish, Persian Rose, Improved Havana, and Brazilian American, were tested in 1892. Of these, Comstock Spanish, Persian Rose, Improved Havana, and Brazilian American are cigar-leaf varieties, and the rest are designated as bright-leaf varieties. On fertilized, red, sandy land the yields of cured tobacco per acre ranged from 900 to 1,530 pounds, and on unfertilized, red, sandy soil, from 399 to 1,200 pounds; on fertilized, gray, sandy soil the range of yield was from 1,050 to 1,680 pounds; on unfertilized, gray, sandy soil, from 810 to 1,170 pounds; on fertilized new land, from 120 to 600 pounds; and without the application of fertilizers, from 60 to 420 pounds. The bright-leaf varieties, with the exception of White Burley, produced a leaf which cured a lemon yellow, but the leaf of the cigar varieties cured too bright. The bright-leaf varieties succeeded best, Hester and Ragland Improved leading, with Conqueror, Long-leaf Gooch, and Sweet Oronoko closely following. The cigar varieties produced lighter yields and a poorer quality of leaf. The use of fertilizers improved the quantity and quality of the crop.

The results of tests made in 1893[2] showed that Conqueror, Long Leaf Gooch, Hester, Oronoko, and Ragland Improved cured brighter than other bright-leaf varieties, and that Vuelta de Abajo, Havana Seed-leaf, Imported Havana, Choice Havana, Little Dutch, and Pumpelly produced a leaf of greater silkiness and finer texture than other cigar varieties tested.

In 1895[3] it was found that White Stem Oronoko, Little Oronoko, Sweet Oronoko, Oak Hill Yellow, Hyco, Long-leaf Gooch, and Ragland Improved cured bright yellow more readily and uniformly than other varieties of bright-leaf tobacco grown in the experiment. During the same season the cigar varieties, Improved Havana, Connecticut Seed-leaf, and Little Dutch were grown at the Louisiana State Station at Baton Rouge. Improved Havana yielded a softer leaf and produced the largest percentage of wrappers; Connecticut Seed-leaf stood next in value, and Little Dutch last. The leaves of Little Dutch were too dark and heavy for cigar wrappers, as would be expected. No investigations seem to have been made of the qualities after fermentation, which is the only condition under which cigar types can be judged.

Several varieties of tobacco from Virginia, North Carolina, Florida, Connecticut, and Cuba were grown at the Alabama State Station in 1892.[4] The Cuban varieties matured first and were ready for cutting

[1] Louisiana Stations Bul. No. 20, 2d ser.

[2] Ibid. No. 25, 2d ser.

[3] Ibid. Nos. 33 and 34, 2d ser.

[4] Alabama State Station Bul. No. 44.

early in August, but wet weather had forced their growth and the product was poor in quality. The varieties from Virginia, North Carolina, and Connecticut did not ripen until September. A number of cigar varieties were grown in 1894.[1] Of these, Comstock Spanish produced a large, bright, thin leaf of good cinnamon color and large enough for wrappers, and Connecticut Seed-leaf a fine leaf somewhat lighter in color and smaller in size. Havana Seed-leaf and Havana produced fillers and binders. The leaf produced by Brazil Gold-leaf was thin and silky and brighter in color than the leaves produced by any of the other varieties grown, All these varieties had a decided cigar flavor with the exception of Brazil Gold-leaf.

From 1891 to 1893, inclusive, the Maryland Station[2] made a comparison of improved and introduced varieties of tobacco and the common or native sorts grown within the State. The following varieties were grown: Bonanza, Boyer or Tall Pear Tree, Bradley Broad-leaf, Broad-leaf Thick-set, Bullion, Climax, Connecticut Seed-leaf, Conqueror, Gold-finder, Havana, Hester, Hybrid Havana, Hyco, Lancaster County Seed-leaf, Long-leaf Gooch, Long Red, Narrow-leaf Thick-set, Oronoko White Stem, Pennsylvania Seed-leaf, Persian, Red Burley, Saffrano, Thesis, Tilley, Tuckahoe, White Burley, Yellow Oronoko, Yellow Pryor, and Zimmers Spanish. The best results were obtained from the varieties ordinarily grown in Maryland and from seed produced within the State.

Experiments carried on at the Colorado Station[3] in 1889 led to the conclusion that nothing but Havana Seed-leaf should be grown in that region. Tobacco from seed grown at the station was found to be much inferior to that grown from imported seed. Since that time no further work on tobacco has been reported by the station.

Among the earliest and best yielding varieties tested at the Central Experimental Farm at Ottawa, Canada,[4] were White Burley, Connecticut Seed-leaf, Pennsylvania Seed-leaf, Yellow Prior, Climax, Yellow Mammoth, Yellow Oronoko, Saffrano, Brazilian, and Canadian. In 1896 White Burley had matured, when a frost in September greatly injured later sorts. Connecticut Seed-leaf and White Burley are reported as being extensively grown in the Province of Quebec and in western Ontario.

In connection with a chemical study of the tobacco plant by the Virginia Experiment Station[5] in 1892, it was found that Bradley Broad Leaf and Yellow Oronoco contained a larger proportion of leaf than Gold Finder or White Burley. In these varieties the leaves comprised 59.77 and 60 per cent, respectively, of the total weight of the plant,

[1] Alabama State Station Bul. No. 64.
[2] Maryland Station Bul. No. 26.
[3] Colorado Station Bul. No. 10.
[4] Canada Cent. Expt. Farm Bul. No. 30.
[5] Virginia Station Bul. No. 14.

and the stalks 21 and 20 per cent. The average for all four varieties was 55 per cent of leaf, 21.9 per cent of stalk, and 23.1 per cent of root.

In planning future work on the varieties of tobacco it is very important to keep in mind the purpose for which the tobacco is intended. The kind of tobacco grown in any district depends in part upon the climatic conditions and in part upon the character of the soil. The industry has become so highly specialized that a nondescript tobacco has very little market value at the present time. In testing varieties, therefore, consideration should be given in the first place to the type of tobacco adapted to the locality and to the soil and the grade which the climatic conditions and soil may reasonably be expected to produce. For example, in the Connecticut Valley the most important question is, What is the best variety for producing a thin wrapper leaf of from 14 to 18 inches in length, having certain characteristics which are possessed by the Sumatra wrapper, the present standard of excellence for cigar wrappers in this country? On the heavier limestone soils of Pennsylvania and in the Ohio district, where a filler type is grown, the question is, What variety will give the small, highly-flavored leaf, approaching the Cuban tobacco in quality, in flavor, and in aroma?—the Cuban-leaf being the present standard for filler tobacco for cigars in this country.

One difficulty the experiment stations have found in the tobacco investigations is the fact that the finest qualities of the leaf are developed only after certain fermentation or other changes have taken place in the cured leaf. Most of the stations have not been prepared to manipulate the tobaccos so that a reliable estimate of their commercial value could be given.

INFLUENCE OF DISTANCE IN PLANTING ON THE YIELD AND THICKNESS OF THE LEAF.

At the Wisconsin Station a study of the relation of distance of planting to yield and thickness of leaf was made in 1894 and 1895.[1] In 1894 plants were set 20 inches apart in rows 31 and 36 inches apart and 24 inches apart in rows 42 inches apart. Close planting increased the yield, and the plants nearest together in the row produced a thinner leaf than plants set farther apart, but lessening the distance between the rows did not have this effect. A distance of 31 inches between the rows was sufficient for the full development of the plants. The surface area of the cured leaves per pound from the closest planting was 42.01 square feet, and from the widest planting 40.86 square feet.

In 1895 experiments were made with a view to ascertain to what extent close planting may be advantageously practiced. The plants were grown in rows 1, 1½, and 2½ feet apart with the distance between

[1] Wisconsin Station Rpts. 1894 and 1895.

plants in the row 1, 1, 1½ feet, respectively. In this experiment the surface area per pound of cured leaf was 60.64 square feet for the closest planting, 48.34 square feet for the next closest, and 47.40 square feet for the widest planting. The percentage of fillers produced ranged from 10.19 per cent for the widest planting to 16.40 per cent for the closest planting.

Close planting gave a large increase in yield and diminished the size and thickness of the leaf. The difference in the size and thickness of the leaf between plants grown 1½ by 2½ and those grown 1 by 2½ feet was not so marked as the difference in the yield, and this effect is considered as showing that planting 1 foot apart in the row was not too close for Wilson Hybrid, the variety grown in this experiment.

The experience of the Massachusetts Hatch Station[1] with regard to distance of planting was that planting 3 feet 4 inches by 1 foot 8 inches and 2 feet 8 inches by 2 feet gave better returns than planting 3 feet by 1 foot 6 inches. The author concludes that too close planting interferes with the development of the leaves, while too large spaces between plants tend to produce coarse leaves.

The Florida growers have shown the great importance of the proper distance in planting in the improvement of the quality of tobacco. Mr. M. L. Floyd[2] briefly cites the methods used by the Florida growers:

> In order to improve the tobacco and adapt it to the trade demands, these concerns have indulged in all sorts of experiments, some of which have proved quite expensive. However, they have met with such a degree of success as to warrant them in continuing the experimental work. There were many questions to be settled. First of all, what seed should be used. To settle this question seed was obtained and tried from every part of the country. This point, however, was soon determined and now there are only two varieties grown in the State—Sumatra and Cuban—the Sumatra giving the style required for the wrapper and the Cuban giving the filler qualities nearest the requirements of the trade. As each of these tobaccos possesses the quality and style needed, the kind of soil best suited to each was the next point to be settled; then the proper fertilizer, the quantity necessary, and the proper cultivation had to be found out by numerous experiments. At first it was thought that but little fertilizer of any kind should be used. The tobacco was set out early, given a distance in the drill of about 24 inches, and topped low; that is, not more than twelve or fourteen leaves were allowed to each stalk. The result was that the plants produced large, coarse, undesirable leaves. The next step was to give the tobacco less distance in the drill; 18 inches were tried. The result was better, but not satisfactory. From time to time changes were made until now the plant is given 14 inches, the fertilizer is doubled, and the tobacco is topped higher, allowing at least sixteen leaves to each stalk. The result is that the leaves are of the desirable size and finer in quality and appearance.
>
> For a long time the cultivation was continued until the time of harvesting, but this was decidedly wrong. The writer has seen fields of tobacco plowed that were ripe and ready to be harvested, and in consequence the tobacco turned green and

[1] Massachusetts Hatch Station Bul. No. 47.

[2] Report No. 62, U. S. Department of Agriculture, Cultivation of Cigar-leaf Tobacco in Florida, p. 22.

started a new growth. This generally increases the yield, but almost totally destroys the quality of the tobacco. At present the cultivation stops as soon as the plants are topped.

When the Sumatra seed was first introduced into Florida, the land selected, the amount of fertilizers used, and the methods of cultivation and harvesting employed were the same as those practiced in growing the Cuban variety. With this treatment Sumatra proved to be an absolute failure; many abandoned the seed, while others continued to experiment. It was soon found that the soil had to be exceedingly rich, the growth quick; that low topping was ruinous, and that each stalk should have from twenty-four to thirty leaves, according to the strength of the soil. When the land was exceedingly rich it was found best not to top at all, but to allow the plants to go to bloom. Then the leaves would be of desirable size, thin and smooth; whereas if topped the leaves would curl and thicken. This tobacco is also crowded into the drill, the plants being given only from 12 to 14 inches. The growth is rapid; the top leaves soon serve as a shade for the middle and lower leaves, and the results have been most gratifying. New land proved to be more desirable for this variety of tobacco, and it was noticed that when trees were left standing in the field the plants shaded by trees were far superior to the plants not so shaded. From this the idea of building artificial shade had its birth. It was also found that no good results could be obtained if the plants were cut, but the leaves should be primed off just as they ripen, and at a very early stage of ripeness.

Further experiments along these lines are very much to be desired, but the purpose of the investigation should be determined beforehand and the work should tend toward certain ends. For example, to use an illustration already referred to, the Connecticut growers are interested in the production of a fine wrapper leaf of moderate size, small veins, elastic, and with very little flavor. The size of the leaf, thickness, elasticity, and size of the veins may all be more or less modified by giving space or by crowding in the row. The undesirable qualities of the Connecticut wrapper should be recognized, as has been done in the case of the Florida tobacco, and such qualities eliminated by attention to just such conditions as the distance apart in the row and the height at which the plants should be topped. On the heavier soils of Pennsylvania, on the other hand, efforts should be directed to the production of a highly flavored leaf of moderate size. These are qualities which can also be sensibly affected by the distance of planting and by the time and manner of topping. In the same way in the development of the tobacco industry in the export and manufacturing districts, the undesirable qualities in the leaf may often be eliminated by a change in the method of planting, cultivation, or topping of the tobacco.

FERTILIZER EXPERIMENTS.

Fertilizer tests with tobacco were conducted at the Kentucky Experiment Station during several seasons. The results of experiments made in 1889[1] indicated that muriate of potash and sulphate of potash gave equally good results as fertilizers for tobacco and that nitrate of soda

[1] Kentucky Station Bul. No. 28.

produced a better quality of leaf than other forms of nitrogen. A test with complete and incomplete fertilizer applications for tobacco was made in 1892.[1] A yield of 1,460 pounds of cured leaf per acre was obtained from an application of 80 pounds of nitrate of soda, 80 pounds of dried blood, 160 pounds of muriate of potash, and 140 pounds of double superphosphate per acre and a yield of 1,620 pounds was obtained from an application of double these amounts. An application of 160 pounds of muriate of potash per acre resulted in a yield of 1,390 pounds of cured leaf but the crop was poor in quality. Potash applied alone gave better returns than when applied with nitrate of soda and dried blood or double superphosphate. The complete fertilizer mixtures produced the best yields and the heavy application the best financial results.

In 1893[2] fertilizers were used on soil in a good state of fertility. An application of 300 pounds of carbonate of potash and magnesium, 160 pounds of nitrate of soda, and 140 pounds of double superphosphate per acre increased the yield of cured leaf by 255 pounds per acre and, when 160 pounds of muriate of potash was substituted for the carbonate of potash and magnesium, the yield was increased 265 pounds. Incomplete fertilizer mixtures were least effective.

In 1895[3] the experiments were conducted under rather unfavorable conditions. The author concludes from the results obtained that satisfactory results may be obtained on worn Kentucky soils by applying potash fertilizers, especially when used in connection with nitrogenous fertilizers.

The results obtained in 1896[4] confirm the conclusions of the previous season.

The Maryland Station conducted fertilizer tests in different tobacco-growing sections of Maryland in 1891[5] and 1892. Dissolved South Carolina rock and dissolved bone black proved to be profitable sources of phosphoric acid, and high-grade sulphate of potash followed by cotton-seed hull ashes was found to be the best form of potash. The author concludes that nitrogen should be applied in two forms: One-half as nitrate of soda and the other half in some organic form, such as dried blood or tankage.

In 1892 the North Louisiana Experiment Station at Calhoun[6] conducted fertilizer experiments with tobacco on red sandy and gray sandy soil. Potash had little or no effect on the increase of the crop, but nitrogen either in the form of nitrate of soda, sulphate of ammonia, cotton-seed meal, or dried blood caused a marked increase in the quantity produced. An application consisting of cotton-seed meal, acid

[1] Kentucky Station Bul. No. 45.
[2] Ibid. No. 55.
[3] Ibid. No. 63.
[4] Ibid. No. 66.
[5] Maryland Station Bul. No. 26.
[6] Louisiana Stations Bul. No. 20, 2d ser.

phosphate, and sulphate of potash produced the best quality of leaf. These tests were continued in 1893,[1] and the results indicated that nitrogen was needed most, while potash was the least necessary. Complete fertilizer mixtures gave the best results, in some cases increasing the yield over 100 per-cent as compared with a crop grown without the use of fertilizers.

The results of the work carried on in 1894 and 1895[2] confirm the conclusions drawn from the experiments of the preceding seasons and indicated that cotton-seed meal was the best and cheapest source of nitrogen for the tobacco crop in that region. Since potash had shown itself least effective in this series of experiments it is concluded that cotton-seed meal and acid phosphate is the best tobacco fertilizer mixture for the soils on which the experiments were made.

The effects of different fertilizers on tobacco were studied at the Virginia Station[3] in 1890. Five plats fertilized with complete fertilizers, all of the same cost per acre, were compared with an unfertilized plat. As a source of nitrogen, dried blood gave the largest yield and the best financial returns. Dried blood in connection with nitrate of soda also gave good results, and where these fertilizers were applied, either in combination or separately, the tobacco fired very little as compared with the tobacco grown on the unfertilized plat. There was also much more stalk rot on the unfertilized plat than on the other plats. The plat which had received sulphate of ammonia, sulphate of potash, and acid phosphate suffered most from field fire and gave smaller returns than any other of the fertilized plats. The tobacco grown without fertilizers ripened from ten days to two weeks later than the tobacco grown with fertilizers.

In 1893 the Pennsylvania Station[4] made some experiments to determine the relative values of various fertilizers for tobacco. The use of fertilizers increased the size of the wrapper leaves, and an application of double carbonate of potash and magnesium, contrary to the claim sometimes made for it, had no restraining effect on the size of the leaf. The loss in sweating the crop was greatest where barnyard manure had been used. Phosphoric acid in the form of dissolved bone black showed a tendency to thicken the leaf, and nitrate of soda produced a very dense leaf. Double carbonate of potash and magnesium produced a thinner web than sulphate of potash, but had little effect upon the vein. As to burning quality, no decided differences were noticed, except that the duration of glow was least in the crop fertilized with barnyard manure.

In connection with soil tests made by the North Carolina Sta-

[1] Louisiana Stations Bul. No. 25, 2d ser.
[2] Ibid. Nos. 33 and 41, 2d ser.
[3] Virginia Station Bul. No. 12.
[4] Pennsylvania Station Bul. No. 30.

tion[1] in 1891 and 1892 it was found that the application of fertilizers furnishing nitrogen and phosphoric acid produced the best quality of leaf, while fertilizers supplying nitrogen and potash gave the best results in yield and total value of crop. Potassium chlorid as a source of potash was more profitable than kainit or potassium sulphate, but the use of the sulphate resulted in a better quality of leaf as compared with the other forms of potash.

Field experiments with tobacco were conducted by the Massachusetts Experiment Station[2] at three different points in the Connecticut Valley within the State during three seasons, from 1893 to 1896. The different fertilizers applied had a greater effect upon the quality of the crop than upon the yield. Cotton-seed meal, linseed meal, and castor pomace, when used in connection with an amount of nitrate of soda or nitrate of potash sufficient to furnish one-fourth of the nitrogen needed by the crop, proved equally good as sources of nitrogen. Nitrate of soda applied with acid phosphate or dissolved bone black produced a better quality of tobacco than nitrate of potash under the same conditions. Cotton-seed hull ashes, followed by high grade sulphate of potash, were observed to be the most valuable sources of potash. Nitrate of potash produced excellent results when used in connection with an alkaline phosphate, such as phosphoric slag meal or with carbonate of potash and magnesia. Potash-magnesia sulphate as the main source of potash did not give encouraging results. The author classifies the fertilizer mixtures used in these experiments as follows:

First class.

Nitrate of soda, cotton-seed hull ashes, and castor pomace.
Nitrate of soda, cotton-seed hull ashes, and cotton-seed meal.
Nitrate of potash, cotton-seed hull ashes, and cotton-seed meal.
Nitrate of potash, carbonate of potash-magnesia, and phosphatic slag.

Second class.

Nitrate of soda, high grade sulphate of potash, cotton-seed meal, and dissolved bone black.
Nitrate of soda, high grade sulphate of potash, linseed meal, and dissolved bone black.
Nitrate of soda, high grade sulphate of potash, castor pomace, and dissolved bone black.

Third class.

Nitrate of potash, potash-magnesia sulphate, cotton-seed meal, and dissolved bone black.
Nitrate of potash, potash-magnesia sulphate, castor pomace, and dissolved bone black.

[1] North Carolina Station Bul. No. 89.
[2] Massachusetts Hatch Sta. Bul. No. 47.

This classification is based on the difference in color and compactness of the ash of the tobacco grown with the different fertilizer applications. Since these differences were slight in several instances the classification is considered as somewhat arbitrary.

The most extensive series of fertilizer tests on tobacco reported by the experiment stations was made by the Connecticut State Experiment Station [1] in connection with the Connecticut Tobacco Experiment Company during the seasons of 1892 to 1896, inclusive. The experiments were conducted on 28 plats on which different fertilizers or different amounts of fertilizers were applied, and the conclusions drawn are based upon the average results for four or five years. An application of 210 pounds of nitrogen per acre, either in the form of cotton-seed meal or castor pomace, produced larger crops, a greater percentage of wrapper leaf, and a better quality of tobacco than an application of 175 pounds or 105 pounds of nitrogen. A comparison of cotton-seed meal and castor pomace as tobacco fertilizers showed that castor pomace produced on an average for five years 25 pounds of wrappers more per acre than cotton-seed meal, but the average quality of leaf raised with cotton-seed meal was somewhat better than that of leaf grown with castor pomace. Linseed meal as a source of nitrogen produced on an average for four years 157 pounds of wrappers per acre less than castor pomace and 65 pounds less than cotton-seed meal, but the quality of the leaf from the linseed-meal plat was decidedly better than from the other two. The average results of a comparison of dry-ground fish and cotton-seed meal, carried on for four years, showed that dry-ground fish yielded 257 pounds of wrapper leaf per acre less than cotton-seed meal, but in quality of product the plat fertilized with dry-ground fish ranked fourth among the entire number of plats, while the other plat ranked seventeenth. Dry-ground fish produced 56 per cent of wrappers in the crop, and the cotton-seed meal 63 per cent.

Applying one-half of a dressing furnishing 210 pounds of nitrogen per acre, in the form of nitrate of soda, when the crop was nearly half grown, instead of applying the whole amount of nitrogen in the form of castor pomace prior to setting out, the crop produced a heavier yield of tobacco suitable for wrappers, but it reduced the quality of the leaf so that there was no economy in the practice. The average yield for four years of tobacco fertilized with tobacco stems was 976 pounds of wrappers per acre, as compared with a yield of 681 pounds for the crop grown with stable manure, but the stable manure produced a better quality of leaf than the tobacco stems. Taking into consideration the results obtained with stable manure and cotton-seed meal the author recommends supplementing an application of stable manure

[1] Connecticut State Station Rpts., 1892, 1893, 1894, 1895, 1896, 1897.

with some quickly available form of nitrogen, such as cotton-seed meal.

A study was also made of the effects of various forms of potash on the quantity and quality of tobacco. The plats fertilized with some form of carbonate of potash produced a smaller yield than the average yield for all the potash plats, while the plats which received potash in the form of sulphate yielded more than the average. Sulphate of potash produced tobacco which had slightly heavier leaves, and which did not hold fire quite so long as tobacco produced by the use of some form of carbonate. In general the crops fertilized with pure carbonate of potash, wood ashes, double carbonate of potash and magnesia, and cotton-hull ashes were of better average quality than the crops fertilized with high-grade sulphate of potash and double sulphate of potash and magnesia, either with or without lime. The addition of lime had little effect on the quality of the leaf.

IRRIGATION OF TOBACCO.

The effects of irrigation on the product of tobacco were studied by the Wisconsin Station[1] during two especially dry seasons. In 1893 the crop was irrigated twice and the yield, as compared with the yield of unirrigated land, showed an increase of 23 per cent in the weight of the uncured crop, 33 per cent in the weight of the cured stalks, and 7 per cent in the area per pound of cured leaf. The weight of the total crop of cured leaves from the irrigated and unirrigated plats was practically the same, showing that the increase in the weight of the green crop was almost entirely due to the increase in the weight of the stalks. One hundred cured leaves of average size selected from tobacco grown under irrigation weighed about 13 per cent more than the same number of leaves similarly selected from the plants grown without irrigation.

In 1894 only one irrigation was given. The increase due to irrigation in the weight of the green crop was 7.35 per cent, in the weight of the cured leaves 6.96 per cent, and in the area per pound of cured leaf 1.7 per cent. After the crop had been cured 800 sound leaves were selected from the plants grown with and without irrigation and weighed. The leaves from the irrigated plat weighed 2.92 per cent more than those from the unirrigated plat. It was noticed that the plants were more readily broken down by heavy winds on the irrigated plat than on the other. A better yield of cured leaf was obtained in 1894 with one irrigation than in the preceding year with two irrigations. It was shown during the two seasons that irrigation perceptibly increased the yield and produced a thinner leaf, as com-

[1] Wisconsin Station Rpt., 1894.

pared with tobacco grown without irrigation, but that there was no other noticeable difference in the quality of the leaf.

A practical experiment on a commercial scale has been started in Florida in the irrigation of the Sumatra type of wrapper leaf. The first crop is reported to be of the finest quality that has ever been grown in the State, containing a larger proportion of first-class wrappers. The experiments are being continued and extended. Next year it is proposed by a single company to put 200 acres under the ditch. It is not only necessary in this case to provide the water supply, but the distance of planting, method of cultivation, and time and manner of topping must all be controlled in reference to the variety of tobacco planted and the grade it is proposed to produce—whether a wrapper or a filler leaf.

In the same line the practice of shading tobacco in Florida may be mentioned. This prevents the excessive evaporation from the plants as well as from the soil, and has had a marked effect in improving the quality of the wrapper leaf and in increasing the percentage of wrapper leaf in the crop.

An older method of irrigating in Florida, by the use of overhead sprays, was reported in Bulletin No. 13 of the Division of Soils. This method is not believed to have been as economical or as successful as the present method of subirrigation from wooden troughs laid in the ground.

INFLUENCE OF TIME OF HARVESTING ON THE YIELD AND THICKNESS OF THE LEAF.

Experiments were undertaken at the Wisconsin Station[1] in 1895 with a view to determining whether the tobacco leaf increased in size and thickness and whether the loss in curing diminishes when the plants are allowed to stand a considerable time after topping.

Tobacco plants were topped August 2 and 6 and the leaves were picked at different times, varying from eighteen to thirty-two days after topping. Upper leaves were selected as samples from which data were determined. The results indicate that the thickness and dry matter of the leaf tended to increase up to thirty-two days after topping, and the yield showed a tendency to increase in like manner. Cured samples which had been harvested eighteen days after topping had a weight of 459.2 grams and an area per pound of cured leaf of 47.81 square feet as compared with the weight of 577.55 grams and an area per pound of cured leaf of 41.39 square feet for cured samples harvested twenty-seven days after topping. There was no material difference in the percentage of loss in curing between the various samples.

[1] Wisconsin Station Rept., 1895.

Practical growers in all of the tobacco districts have for years experimented upon this subject and very marked results have been attained in the production of an article suited to the market demands. It is quite possible to vary the commercial grade and influence the price considerably by harvesting the crop at different stages of ripeness. This has been taken advantage of in many cases in catering to many trade requirements. It is one of the methods by which the quality of the tobacco can be sensibly controlled.

EFFECT OF PRIMING TOBACCO PLANTS.

Priming consists in removing the leaves of the tobacco plant as they mature.

It was noticed in connection with curing experiments at the North Carolina Station[1] that priming had a marked effect on the growth and chemical composition of the upper leaves. Removal of the lower leaves caused an increased growth in the upper leaves and with it an increase in percentage of nitrogenous matter and nicotine. The quality of the product was thus somewhat lowered by priming, but the gain in weight more than compensated for the loss in quality.

Priming the leaves from the stalk as they ripen is believed by many practical tobacco growers to be the proper method of harvesting the cigar and cigarette types, for in this way alone can the tobacco be saved just at the proper stage of ripeness. Priming does not impair, but improves, the quality. The increase in pounds is simply due to the fact that the upper leaves are allowed to remain on the stalk until they are fully developed and matured. The priming of tobacco is more expensive than cutting the stalk, as more labor is required, but the improvement in quality fully warrants this additional cost.

The method of priming is very generally used now with the bright yellow leaf of Virginia and North Carolina, and with the Sumatra type of wrapper leaf in Florida. It has the advantage that the leaves are uniformly matured when they are hung in the barn, and the finished crop is therefore of a more uniform character. In priming it is usual to go over the crop three or four times, finally cutting the stalk with the top leaves attached.

EXPERIMENTS IN TOPPING TOBACCO.

The Central Experimental Farm at Ottawa, Canada,[2] conducted experiments in topping tobacco plants in order to determine how the time of topping and the number of leaves left on the plants affect the yield. The plants were topped July 20 and 26 and August 2, and on each date one plat was cut back to 9 leaves and another to 11 leaves per

[1] North Carolina Station Bul. No. 90a.

[2] Canada Experimental Farm Report, 1897.

plant. Early topping caused the plants to throw out suckers freely, but this tendency diminished as the topping was done later. It was found sufficient to remove the suckers from the later topped plants once, while from the plants topped on the two earlier dates they had to be removed at two different times. The larger yields were obtained from the latest topping and the greater number of leaves per plant.

The time for topping a tobacco plant is when the seed bud has well put out. If the soil is rich and the tobacco has the proper distance only the seed bud should be taken out; all leaves should be allowed to grow. It is often necessary to remove the suckers three or four times after topping.

The time and manner of topping has a great influence upon the character of the leaf produced. As a rule the earlier a plant is topped and the lower it is topped the heavier, richer, and darker-colored the leaves become. This is a decided advantage for some crops, but a disadvantage to others. In the production of the finest quality of Sumatra wrappers in Florida the practice has recently grown up of topping very high, and, indeed, in wet seasons or on heavy soils, where the plants are making a luxurious growth, the plant is allowed to go to seed in order to keep the leaves as small and thin as possible.

YIELD OF TOBACCO.

The yield of tobacco, like that of other crops, is the product of all the factors of growth and, as these are not constant, but vary considerably with time and place, the yields vary at different times and in different sections of the country. The results obtained at different experiment stations in connection with experimental work are here briefly noted:

At the North Louisiana Experiment Station[1] at Calhoun in 1892 the average yields of bright leaf and cigar varieties on different experimental plats varied from 712 to 1,280 pounds of cured leaf per acre, respectively, on fertilized and unfertilized plots; in 1893[2] an acre of bright tobacco yielded 592 pounds of cured leaf, and 11 varieties of cigar tobacco, grown on fertilized red sandy soil, yielded on an average 1,046 pounds per acre, while an acre of land at Shreveport, La., under the management of the station, yielded at the rate of from 1,400 to 1,600 pounds of cured cigar leaf and from 1,600 to 1,800 pounds of bright leaf; in 1894[3] the average yields of cured leaf per acre of cigar and bright leaf varieties in connection with soil, variety, and fertilizer tests, ranged from 359 to 1,086 pounds per acre; and in 1895[4] the results of similar work varied from 505 to 788 pounds per acre in the yield of cured tobacco of yellow leaf and cigar varieties.

[1] Louisiana Stations Bul. No. 20, 2d ser.
[2] Ibid. No. 25, 2d ser.
[3] Ibid. No. 33, 2d ser.
[4] Ibid. No. 41, 2d ser.

At the Alabama State Station[1] in 1893, cigar varieties on upland and bottom sandy soils ranged in yield from 439.4 to 1,505.4 pounds, and plug tobaccos from 575.4 to 1,744.6 pounds of cured leaf per acre.

The North Carolina Station[2] reports yields of cured leaf ranging from 665.5 to 1,542.7 pounds per acre.

Long-leaf Gooch tobacco, grown in connection with fertilizer tests at the Virginia Station in 1890,[3] yielded 762 pounds of cured tobacco on the check plat and 1,035 pounds per acre on the most productive fertilized plat.

Plat experiments with fertilizers for tobacco at the Maryland Station[4] in 1892 resulted in yields of cured tobacco per acre varying from 440 on the unfertilized to 820 pounds per acre on the fertilized plats.

At the Kentucky Station[5] in 1895 White Burley yielded from 555 to 1,499 pounds of cured leaf per acre, and in 1896[6] the yields of experimental plats varied from 500 to 1,295 pounds of cured leaf per acre.

In experiments carried on by the Massachusetts Hatch Station,[7] at Hatfield, Agawam, and Westfield, Mass., for three successive years, the yields of cured leaf varied from 1,379 to 1,648 pounds per acre. The percentage of wrapper leaf in these crops ranged from 21.2 to 69.6 per cent.

In connection with the fertilizer experiments carried on for five years in succession by the Connecticut State Station,[8] the yield for all plats for the entire period averaged 1,685 pounds of assorted leaf per acre. The average yields for the different years ranged from 1,569 to 1,876 pounds. The heaviest yield obtained from any one plat was at the rate of 2,280 pounds per acre. The average yield of wrappers for the five years was 60.7 per cent of the total yield, with a range from 47.2 to 66.2 per cent for the different seasons. On some plats as high as 78 per cent of the product was suitable for wrappers.

Estimated yields, based on the results obtained on experimental plats at the Wisconsin Station in 1893 and 1894,[9] varied from 1,484 to 3,841.5 pounds of cured leaf per acre.

On small experimental plats at the Central Experimental Farm, Ottawa, Canada,[10] the rate of yield has been estimated in different seasons from about 1,500 to 2,500 pounds of cured leaf per acre.

The question of the actual yield of tobacco is an important consideration under certain circumstances, but is a matter of little interest in other cases. In the cigar districts, particularly, the influence of quality on the price is so great that the actual yield is hardly a matter for consideration. At the same time other factors enter in, as the price

[1] Alabama State Station Bul. No. 54.
[2] North Carolina Station Bul. No. 89.
[3] Virginia Station Bul. No. 12.
[4] Maryland Station Bul. No. 26.
[5] Kentucky Station Bul. No. 63.
[6] Ibid. No. 66.
[7] Massachusetts Hatch Station Bul. No. 47.
[8] Connecticut State Station Rpt., 1897.
[9] Wisconsin Station Rpts., 1894 and 1895.
[10] Canada Central Exptl. Farm Bul. No. 30.

of labor in the grading and sorting of the finer grades. It is often more profitable to raise a large quantity of inferior leaf than to raise a small weight per acre of a finer leaf which can not be economically sorted. This question, therefore, depends to a very great extent upon local conditions, and especially upon labor conditions.

DISEASES OF TOBACCO.

The diseases to which most attention has been given are those which manifest themselves during the curing process and which are commonly known as stem rot and pole burn. This latter disease is also referred to as "pole sweat" and "house burn." Both of these diseases were observed and studied by the Connecticut State Station during several seasons. As observed by this station,[1] pole burn makes its appearance as small dark spots on the surface of the leaf near the veins and midrib, where moisture is most abundant. These spots rapidly increase in size, soon becoming confluent, and within thirty-six to forty-eight hours the whole leaf may be affected and the entire contents of the curing barn destroyed. The tobacco changes in color from a green yellow to a dark brown, or almost black, loses its fine texture, and reaches such a stage of decay that the leaves are separated from the stalk by their own weight. From investigations made at the station and results obtained by other investigators of this same subject, the author infers that the disease is due primarily to a fungous growth which attacks the leaf on the surface and gives access to a bacterial process of decay by disintegrating and partially destroying the leaf tissue.

Cultures of the bacteria which caused this rapid decay of the leaf were studied in the laboratory, and it was ascertained that moisture and temperature have a marked effect on the activity of these organisms. Decreasing the amount of moisture decreased their vitality, and a temperature up to 70° F. or even 90° F. favored their development, while temperatures of over 100° or 110° and below 35° or 40° temporarily or permanently checked their vitality. Attempts to inoculate thoroughly cured tobacco with the bacteria were unsuccessful. The author concludes from his study that pole burn can be prevented by a proper regulation of moisture and temperature.

In 1893,[2] although conditions were most favorable for curing tobacco, an experiment was conducted to test the effect of artificial heat on the temperature and relative humidity of the air in a tightly-closed barn filled with green tobacco. A number of observations were made in each case and average results determined. The temperature of the outside atmosphere was 57° F. and the relative humidity 70°. Inside the barn the temperature was 54° and the relative humidity 82°. Opening the end doors and the lowest row of ventilators in fair weather

[1] Connecticut State Station, Rept., 1891. [2] Ibid. 1893.

brought the temperature inside the barn, 6 feet above the floor, to within one degree of the temperature of the air outside, and reduced the relative humidity from 91° to 86° within half an hour. For the test with artificial heat the barn was tightly closed and fire started in two of the four furnaces, thus using only one set of flues. One hour after starting the fire the relative humidity was 69° and the temperature 71.5° F. 6 feet above the barn floor. "By using only half the available heating facilities for one hour, the relative humidity of the interior of the barn at a height of 6 feet from the ground was reduced from 91° to 69°. * * * In conclusion we are justified in considering that, under the atmospheric conditions most favorable to the development of 'pole sweat,' the temperature and moisture in the interior of a closed barn can be so regulated by artificial heat as to reduce to a minimum the liability of curing tobacco to damage from fungi or other like organisms."

No special experiments were made with stem rot, but the author states[1] that this fungus disease which frequently affects the stems of the plants in the last stage of curing seldom matures in the cured stalks, owing to their dryness at this time. As a remedial measure it is suggested that when the crop is cured all stems and refuse attacked by stem rot be burned before the fungus has matured and the barn be fumigated with sulphur immediately after curing a crop and again before the harvesting of the next season's crop. "If this be done * * * the danger from stem rot would be largely decreased if not entirely obviated."

EXPERIMENTS IN CURING TOBACCO.

Experiments with different methods of curing tobacco have been conducted by the experiment stations of a number of tobacco-growing States. In a series of experiments made in Maryland and reported by the Maryland Experiment Station[2] tobacco was air and flue cured in a frame barn and flue cured in a log barn. Owing to more favorable conditions of humidity, flue curing gave better results in the frame barn than in the log barn. Results in general were favorable to flue curing as compared with air curing.

At the North Carolina Station in 1891,[3] the ordinary method of cutting down the plant and curing it with the leaves on the stalk proved less profitable than curing by the Snow process, in which the leaves are cut from the stalk as they ripen and cured separately. By the ordinary method 326 pounds of cured leaves were obtained from 2,114 pounds of fresh leaves and stalks, and by the Snow process 454 pounds from 2,109 pounds of green plants. The net financial returns amounted

[1] Connecticut State Station Rpt., 1891. [2] Maryland Station Bul. No. 26.
[3] North Carolina Station Buls. Nos. 86 and 90a.

to $32.89 for the stalk-cured, and $53.55 for the leaf-cured or Snow process. The tobacco cured by the leaf process was better in quality than the leaf cured on the stalks. This effect is ascribed to be due to harvesting the leaves as they became mature, while by the stalk process many of the lower leaves were overripe and the upper leaves still green at the time of cutting. Handling the leaves on the stalks also caused a greater loss than handling them separately. It was found that the time and temperature required for curing leaves from different parts of the plant varied according to their ripeness, and that for this reason the leaf-curing proved the more desirable method, since the leaves cured at one time were all of the same degree of maturity and required like treatment to produce the best results in color, quality, and general appearance. The author states that carefully regulating the drying by artificial heat, as practiced in the Snow curing barn and old style log barn, reduces the fermentative changes in curing to a minimum. It is believed that in these experiments, owing to this fact, practically the whole amount of glucose present in the leaves remained unchanged in the cured product.

The record of temperature in leaf curing is given briefly as follows: The temperature in the barn on August 18, at 9 a. m., was 90°; at 10 a. m., 95°. On August 19, at 10 a. m., 100°; 11 a. m., 105°; 9.30 p. m., 120°. August 20, 10 a. m., 125°; 2 p. m., 130°; 10 p. m., 136°. August 21, 3 a. m., 140°; 6 a. m., 150°; 12 m., 120°, after which the temperature was allowed to fall rapidly and the next morning the tobacco was taken out of the barn. In this process the leaves lost 81.44 per cent of the green weight.

The Pennsylvania Station[1] found that on an average 72.70 per cent of the weight of the whole plant was leaf, and that the cured leaf constituted 15.80 per cent of the weight of the original leaf with stalk-cured tobacco and 14.40 per cent with leaf-cured tobacco. The percentage of leaf tissue was also somewhat greater in the stalk-cured product.

The Wisconsin Station[2] made a series of investigations on the curing of tobacco in 1894, and the results obtained were confirmed by the repetition of the experiments the following season.[3] It was found that the loss of water in curing was about 71 per cent of the weight of the green plant. The rate at which the water passed off increased gradually from the time the leaves were well wilted until their color was changing from yellow to brown. The water appeared to be eliminated by the leaves rather than extracted from them by drying. It is stated that the changes in the color of the leaf during the curing process were not directly due to the loss of moisture, but depended largely upon the degree of ripeness, the riper the leaf the lighter the

[1] Pennsylvania Station Rpt., 1894. [2] Wisconsin Station Rpt., 1894. [3] Ibid., 1895.

shade of brown when cured. From data obtained in this work the author considers it warrantable to conclude that tobacco should be cured in as moist an atmosphere as possible without incurring damage from pole burn. A temperature within the curing house not exceeding 75° F. and a degree of humidity among the plants represented by a wet bulb depression of 2° are regarded as suitable conditions. In order to maintain these conditions the author recommends that the plants should be evenly distributed in the curing house in order to equalize the humidity in the building, and that the ventilation of the curing house should be under perfect control, with a provision to regulate the humidity of the air by the use of artificial heat.

In connection with other experiments in 1895[1] the loss in curing leaves harvested on different dates, from August 24 to September 2, ranged from 85.5 per cent to 87.6 per cent. The percentage of loss in curing was not materially smaller in the later harvested leaves. In one case where the weight of the cured stalks was deducted in addition to the loss of water the loss in curing ranged from 90.77 per cent to 92.58 in four samples.

Experiments with tobacco culture were conducted for several years at the North Louisiana Experiment Station, at Calhoun,[2] and in connection with these the percentage of loss in curing the product was determined. The percentage of loss in curing bright leaf and cigar tobaccos grown with or without fertilizers on red sandy, gray sandy, or new land ranged from about 70 to 90 per cent, but the results did not show that the different types of tobacco or the different soils and methods of fertilization had any special influence on the loss in curing.

In 1897 the Connecticut State Station[3] made a test of curing tobacco on the stalk in a curing room in which the conditions of temperature and humidity were under control. The temperature never went above 88° and seldom over 82°, and the lowest point reached was 59°; but the average temperature for the coldest portion of the twenty-four hours, from 3 to 6 a. m., was 69°. The heat was kept uniform throughout the room, and before the leaves had come to color the humidity was such that they were perfectly limp and hung like damp cloths. The curing was continuous, an advantage derived from the control of the atmospheric conditions within the room. The results of the experiments were so satisfactory that it was repeated on a large scale in a curing barn. Here the results obtained, so far as the work was carried on, were even more satisfactory than in the curing room. The accidental burning of the barn and the tobacco prevented drawing any further conclusions.

[1] Wisconsin Station Rpt., 1895. [2] Louisiana Stations Buls., Nos., 20, 25, 33.
[3] Connecticut State Station Report, 1897.

FERMENTATION OF TOBACCO.

The changes going on in the fermentation of tobacco and their causes have not been studied very extensively by the experiment stations up to the present. The most attention in connection with this subject has been given to the loss or shrinkage in the weight of the leaves, and in several instances the chemical changes which take place during fermentation have been determined. In 1891 and 1892 the Connecticut State Station[1] compared the weight and chemical composition of cured and fermented leaves. The loss in the fermentation of upper leaves, short seconds, and first wrappers was 9.7, 12.3, and 9.1 per cent of their total weight, respectively. About three-fourths of the loss in the short seconds consisted of water; the upper leaves lost almost the same proportion in dry matter, and in the first wrappers the loss of dry matter was a little less than that of water. The nitric acid, ammonia, fiber, and starch content of the leaves was affected very little by the process of fermentation, and the chief loss of dry matter was found to have occurred in the nicotine, albuminoids and amid bodies, nitrogen-free extract, and ether extract. The upper leaves lost over one-third of their nicotine, the short seconds a little less than half, and the first wrappers less than one-sixth. Fermentation seemed to have been most active in the upper leaves, which lost over one-seventh of their nitrogen-free extract and one-fifth of their ether extract. The first wrappers, which constitute a large and the most valuable part of a good crop, lost only 5.8 per cent of their dry matter, this loss being mainly in the ash, nitrogenous matters other than nicotine, and nitrogen-free extract, which includes the "gum" of tobacco. The author does not consider the loss of ash as having been caused by the process of fermentation. The average results obtained by the fermentation of the various experimental crops of tobacco studied by this station for five successive years are of importance in this connection.[2] The average loss of weight due to fermentation in the crops of the different seasons ranged from 8.1 to 14 per cent, but the crop which lost most was not fermented satisfactorily. The average number of leaves per pound of short wrappers was 87 before fermentation and 92 after fermentation, and of long wrappers 64 when cured and 68 when the process of fermentation was completed. The largest number of fermented short wrappers and long wrappers per pound from any one plat was 113 and 98, respectively. It was found that the short wrappers had an average fire-holding capacity of 12 seconds before and 28.5 seconds after fermentation, and the long-wrapper leaves a fire-holding capacity of 9.2 seconds before and 23.9 seconds after they had been fermented.

[1] Connecticut State Station Rpt., 1892. [2] Ibid., 1897.

The Pennsylvania Station[1] found in 1894 that the loss in fermentation was greater with tobacco fertilized with barnyard manure than with tobacco grown with other fertilizers. Applications of double carbonate caused a greater loss in fermentation than the use of sulphate of potash. The smaller leaves lost more than the larger ones, which is considered due to the difference in degree of maturity. Injury from hail and rust is reported as having had no effect on the rate of fermentation.

The fermentation of tobacco is being investigated very thoroughly by the Department of Agriculture, and four reports have already been issued on the subject.[2] These will not be summarized here nor will further comment be made upon the practical development in this line as this has been fully discussed in the publications referred to which can readily be obtained.

COST OF PRODUCING TOBACCO.

The cost of growing tobacco has been studied by only three stations. By two of these stations only estimates are given. At the Georgia Station[3] in 1892 the cost of producing an acre of tobacco, including curing and grading, amounted to $42.07. The cost of producing an acre of cured tobacco at the South Carolina Station[4] in 1898 was $48.05, and, including the expense of preparing and marketing the crop, the cost of production is estimated at $70 per acre. The Colorado Station[5] estimates the cost of producing and marketing one acre of tobacco in Colorado at $78.50.

The cost of producing the Florida tobacco is considered by Mr. Floyd in Report No. 62 of the U. S. Department of Agriculture. He estimates the cost to the large Florida growers when all labor has to be hired at about 18½ cents per pound when cured, with an additional cost of 5 to 8 cents per pound for fermenting, grading, sorting, and packing. The actual outlay to the small farmer, who has much or all of the labor done by himself or the members of his family, is considerably less, but working on small quantities the fermentation and grading can not be so carefully done, and the product is not so valuable.

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[1] Pennsylvania Station Bul. No. 30.

[2] Farmers' Bul. No. 60, Methods of Curing Tobacco. Milton Whitney, 1898.
Report No. 59, Curing and Fermentation of Cigar-leaf Tobacco. Oscar Loew, 1899.
Report No. 60, Temperature Changes in Fermenting Piles of Cigar-leaf Tobacco. Milton Whitney and Thomas H. Means, 1899.
Report No. 62, Cultivation of Cigar-leaf Tobacco in Florida. Marcus L. Floyd, 1899.

[3] Georgia Station Bul. No. 19.

[4] South Carolina Station Rpt., 1898.

[5] Colorado Station Rpt., 1888.

CHEMICAL COMPOSITION OF THE TOBACCO PLANT.

The chemical composition of the tobacco plant has been studied by the stations from various points of view, The different parts of the plant have been analyzed to determine the amount of plant food contained in them. Studies have been made to ascertain the effect of curing and fermenting upon the composition of the leaf and stalk; and the composition of the refuse, such as tobacco dust and tobacco stems, has been determined to show its value as a fertilizing material. A number of analyses of tobacco ash are also reported. The most important results are here briefly summarized.

At the Colorado Station,[1] the analyses of the ash of a number of varieties of tobacco showed that the composition of the samples grown was similar to the average composition of tobaccos produced in Connecticut and elsewhere. One qualitative test for acids in the leaf was made, and acetic, pectic, citric, malic, and oxalic acids were found. The leaves also contained considerable quantities of resinous and fatty substances. The ash of Havana tobacco grown on poor soil was found to contain more than twice as much silica but considerably less lime, potash, and carbon dioxid than the same variety grown on rich soil.

A study of the occurrence of nitrates in tobacco at different stages of growth made at the North Carolina Station[2] pointed out that the nitrates are confined almost entirely to the stalk and stems in the young plants. During the later growth of the plant practically no nitrates were found. Samples of tobacco stems from different sources were analyzed by the station and compared. Stems of cigar tobacco from Missouri, Connecticut, and Ohio and stems of export tobacco from Virginia contained 0.83, 0.72, 0.60, and 0.54 per cent of nitrates, respectively, while stems of cigarette tobacco from North Carolina contained 0.15 per cent. No nitrates were found in North Carolina stems of chewing tobacco or in the dust from the North Carolina product. In general the total nitrogen content was smaller in North Carolina tobacco stems than in those obtained from tobacco grown in the other States mentioned. Whole leaf of North Carolina bright tobacco cured by the leaf-curing process contained 16.23 per cent of potash, while the same kind of tobacco cured by the stalk-curing process contained 21.81 per cent. Other variations in the composition of tobacco resulted from the two methods of curing, but it is believed all these differences in the chemical composition are due mainly to the manner and time of harvesting, and that in general the composition of tobacco cured by similar methods is not materially affected by separating the leaf from the stem before curing if the condition of the tobacco is the same when put into the barn.

[1] Colorado Station Bul. No. 10. [2] North Carolina Station Bul. No. 90a.

Analyses of parts of the tobacco plant at different stages of growth were made at the Virginia Station in 1894.[1] Nearly one-half of the ash of young plants consisted of potash, amounting to three times the content of lime. The percentage of ash in the leaf at four different stages was about the same, increasing slightly from topping until cured. The nitrogen content was nearly 1 per cent higher at the time of topping than when the leaf was cured, while the percentage of phosphoric acid showed very little change, being a little higher when the plants were topped than when cured. The potash was highest at topping and lowest when the leaf was cured, while the reverse was true of lime. Soda was found to be a little lower at topping than at any other time. The percentage of magnesia, sulphuric acid, and chlorin was found slightly increased in the cured state. The plants taken from the plant bed contained, in an air-dried condition, nearly 3 per cent of nitrogen, nearly 1 per cent of phosphoric acid, over 8 per cent of potash, and about 2.5 per cent of lime. Results further show that at the time of topping the whole plant contained about 3 per cent of nitrogen, one-third of 1 per cent of phosphoric acid, about 4 per cent of potash, and over 2 per cent of lime. At the time of cutting it contained nearly 3 per cent of nitrogen, one-third of 1 per cent of phosphoric acid, and more than 3½ per cent of lime.

A series of analyses of different grades of manufacturing tobacco from Virginia, West Virginia, and North Carolina were made by the Virginia Station and reported about the same time as the work described above.[2] The results are of interest in showing to what extent the chemical composition of grades of manufacturing tobacco is subject to variations. The samples analyzed were taken from the crops of 1890 and 1891. The question of varieties was not considered. In the sun-cured tobacco the crop of 1891 in one county contained about one and one-half times as much potash, nearly twice as much sulphuric acid, and one-sixteenth more lime than that of 1890. High-grade bright flue-cured and low-grade bright flue-cured tobacco grown in different counties in different years were found to contain about the same amount of ash, but the low-grade tobacco contained about twice as much nitrogen, phosphoric acid, potash, magnesia, and sulphuric acid as the high grade. The chlorin content of the grades was about the same, but the amount of soda and insoluble matter in the high grade was about six times as much as in the low grade. In one county the potash in the crop of 1891 was about one and one-half times that of 1890, the magnesia and chlorin nearly twice as much, and the insoluble matter about one-fifth as much. The analyses of manufacturing tobacco grown in Virginia agreed very well in their ash content, except in one county, where it was much lower. The potash did not agree

[1] Virginia Station Bul. No. 50. [2] Ibid., No. 51.

except in one or two cases. The lime content varied considerably in all cases and in chlorin and in insoluble matter there was very little agreement. In samples from West Virginia and North Carolina the ash constituents agreed fairly well, but the chlorin varied considerably, varying in the ash from 2.22 to 8.08 per cent. The percentage of ash, nitrogen, and potash was higher and that of lime much lower in the samples from West Virginia than of those from North Carolina.

The Virginia Station[1] shows that in average composition the leaves and stalks do not differ materially except in the nitrogen, of which the leaves contain about two-thirds of 1 per cent more than the stalks. The roots were found to contain on an average nearly 2 per cent of nitrogen, 2 per cent of phosphoric acid, and 1.75 per cent of potash.

The chemical changes in tobacco during fermentation as determined by the Connecticut State Station[2] have been discussed under Effects of Fermentation (p. 28). Complete results of the work are given in the following table:

Analyses of fermented and unfermented leaves.

	Upper leaves.		Short seconds.		First wrappers.	
	Unfermented.	Fermented.	Unfermented.	Fermented.	Unfermented.	Fermented.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Water	23.50	23.40	27.40	21.10	27.50	24.90
Ash	14.89	15.27	22.85	25.25	15.84	16.22
Nicotine	2.50	1.79	.77	.50	1.26	1.14
Nitric acid (N_2O_5)	1.89	1.97	2.39	2.82	2.59	2.35
Ammonia (NH_3)	.67	.71	.16	.16	.33	.47
Other nitrogenous matters	12.19	13.31	6.69	6.81	11.31	11.62
Fiber	7.90	8.78	7.89	8.95	9.92	10.42
Starch	3.20	3.36	2.62	3.01	2.89	3.06
Other nitrogen-free extract	29.39	27.99	26.28	28.36	25.52	26.86
Ether extract	3.87	3.42	2.95	3.04	2.84	2.92

Analyses of tobacco leaves are reported by several experiment stations as given in the following table:

Analyses of tobacco leaves.

Experiment station.	Moisture.	Nitrogen.	Phosphoric acid.	Potash.	Lime.	Magnesia.	Insoluble matter.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Virginia[1]	7.62	4.37	0.502	5.738	5.449	0.956	1.943
Massachusetts State, 1891[3]	11.97	2.95	1.150	6.060	4.830	1.360	2.350
Massachusetts State, 1892[4]	13.05	2.75	.430	7.240	4.170	2.170	4.170
Kentucky[5]	6.80	3.02	.960	6.550	.....	.....	.....

[1] Virginia Station Bul. No. 14.
[2] Connecticut State Station Rpt. 1892.
[3] Massachusetts State Station Rpt. 1891.
[4] Ibid., 1892.
[5] Kentucky Station Rpt. 1895.

BURNING QUALITY OF TOBACCO.

A comparison of the fire-holding capacity of a number of different varieties and types of tobacco was made by the North Carolina Station[1] in 1895. Strips of tobacco leaves were pressed out flat, dried, ignited, and the time noted during which they continued to hold fire. Several parts of the same leaf and different leaves from the same lot were tested in this way and the results averaged. The following table shows the results of these tests:

Burning quality of tobacco.

Variety or type.	Where grown.	Glow, in seconds.	
		Average.	Range.
Domestic Havana Eureka	New York	14	5-35
Cigar leaf wrapper	Florida	117	(a)
London Strips	Kentucky	8	5-25
White Burley	do	7	4-18
Wilson Hybrid	Massachusetts	13	5-28
German Spinning Leaf	Tennessee	11	7-15
Pennsylvania Seed Leaf	Pennsylvania	175	(b)
Havana Seed Leaf	Connecticut	16	4-45
Fancy English Strips	North Carolina	5	4-6
Bright Wrapping Leaf	Virginia	4	2-8
Austrian Wrapper	do	5	3-8
Italian Regie	do	31	10-90
French Regie Snuff Leaf	do	5	3-8
Fine bright mahogany wrapper	do	6	4-8
Ohio Spanish	Ohio	24	8-50
Small dark wrapper	Virginia	24	14-50
Colory Seconds	Maryland	39	15-65
White Burley	Ohio	4	2-6
Yellow tobacco	Georgia	4	2-8
Do	Alabama	6	4-10
Reddish brown	Kansas	6	4-10
Do	Mississippi	6	5-7
White Burley	West Virginia	52	15-150
Seed Leaf	Illinois	12	4-30
Light Brown	Indiana	10	5-25
Spanish type	Tennessee	15	5-40
Bright wrapper (leaf cure)	North Carolina	5	3-7
Bright wrapper (stalk cure)	do	5	4-7
Yellow smoker (leaf cure)	do	8	4-13
Yellow smoker (stalk cure)	do	7	4-12
Yellow cutter (leaf cure)	do	8	4-15

a Burned to end of strip. *b* Burned 2½ in. and put out.

A comparison of the chemical composition of the different samples was made, and it was found that the tobacco having the best burning quality contained a high percentage of ash constituents, and that a large percentage of lime and potash in proper combination and an increased percentage of cellulose were associated with good burning qualities. In general, thin leaves with a delicate structure burned better than coarse, heavy leaves. The results further indicate that albuminoids seem to be injurious to the burning quality, while nicotine seems to be an unimportant factor in this connection.

It is generally accepted that tobacco containing a large amount of chlorids has a low fire-holding capacity, and it has been found that an abundance of potash counteracts the effects of chlorin to a certain extent.

[1] North Carolina Station Bul. No. 122.

This seems to have been verified in the sample of Pennsylvania seed leaf from Pennsylvania, which ranked as one of the highest in fire-holding capacity, although containing nearly 1 per cent of chlorin which, however, was accompanied by a high percentage of potash and lime. The sample of French Regie Snuff-leaf from Virginia had a comparatively high percentage of chlorin, but the potash content was relatively small and its burning qualities poor. The author concludes from this observation that the effect of chlorin may be overcome to a certain extent by the amount of potash present, but that very large amounts would probably not be counterbalanced in this way. Of the several ash constituents, potash and lime are considered most important in promoting combustion.

TOBACCO STALKS AND STEMS AS FERTILIZERS.

Since the stalks of tobacco and the stems of the leaves constitute a large part of the crop, which is usually not removed from the farm, the amount of plant food they contain becomes an item of considerable importance. Analyses of tobacco stems when cut and after curing were made by the Connecticut State Station[1] in 1891. From the data obtained the plant food taken from the soil by the stalks while growing and returned to it when plowed under is determined. It was found that the stalks on an acre of tobacco containing 8,000 plants weigh about 9,500 pounds at the time of cutting, and 3,300 pounds when they have been cured. The average results show that these stalks contain 32 pounds of nitrogen, 8 pounds of phosphoric acid, 49 pounds of potash, 3 pounds of soda, 13 pounds of lime, 5 pounds of magnesia, 5 pounds of sulphuric acid, and 6 pounds of chlorin. The amount of nitrogen, phosphoric acid, and potash in the stalks was greater after curing than at the time of cutting.

Analyses of stalks of different varieties of tobacco made by the Virginia Station[2] show that, on an average, the stalks of air-dried plants contained 3.71 per cent of nitrogen, 0.646 per cent of phosphoric acid, 5.02 per cent of potash, and 2.22 per cent of lime. The stalk is considered as constituting a little less than one-fourth of the average plant. The results of using tobacco stems as a fertilizer for tobacco at the Connecticut State Station have been given under fertilizer experiments (p.). Only one other test of this kind is reported. At the Kentucky Station,[3] soil which had received an application of 4,000 pounds of tobacco stems per acre yielded at the rate of 80.1 bushels of ear corn and 6,270 pounds of fodder per acre as compared with a yield of 47.6 bushels of ear corn and 3,940 pounds of fodder on soil which had received no fertilizer. Tobacco stems were the most effective ferti-

[1] Connecticut State Station Report, 1892. [2] Virginia Station Bul. No. 14.
[3] Kentucky Station Bul. No. 17.

lizer in a series of fertilizer experiments with corn. It is stated, however, that it is not known whether the plats on which this test was made had been fertilized alike prior to the time this experiment was undertaken.

Below are given analyses of tobacco refuse as reported by several experiment stations:

Plant food in tobacco refuse.

Experiment stations.	Tobacco stems.						Tobacco dust.		
	Whole.			Ground.					
	Nitrogen.	Phosphoric acid.	Potash.	Nitrogen.	Phosphoric acid.	Potash.	Nitrogen.	Phosphoric acid.	Potash.
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Connecticut State *a*	1.04	.56	4.98	2.74	.92	10.08	1.91	.52	1.96
Massachusetts Hatch *b*	.....	.....	.....	2.23	.32	6.10	2.08	.42	2.07
New Jersey *c*	1.70	.68	6.17	1.98	.84	9.76	1.21	.32	1.17
Kentucky *d*	2.77	1.03	9.08	.....	.....	.....	.....	.....	.....
Pennsylvania *e*	1.63	.98	7.60	.....	.....	.....	.....	.....	.....

a Stem analysis, Connecticut State Station Rpt. 1897, p.; dust analysis, Rpt. 1896.
b Massachusetts Hatch Station Bul. No. 48.
c Stem analysis, New Jersey Stations Bul. 84, p.; dust analysis, Rpt. 1894.
d Kentucky Station Rpt. 1895.
e Pennsylvania Station Rpt. 1895.

NICOTINE IN TOBACCO.

The subject of nicotine in tobacco was investigated by the North Carolina and Virginia stations. The Virginia station[1] found that the average percentage of nicotine in the air-dry substance of the leaf of White Burley, Medley Pryor, and Yellow Oronoko was 3.46 per cent when the plants were ready to be topped, 3.79 per cent at the time of cutting, and 5.51 per cent when the leaf was cured. At the time of topping the plants there was little difference in the nicotine content of the leaf of the three varieties, while at harvest time the difference was more marked, the nicotine content in the leaf being 3.21 per cent for White Burley, 4.32 for Medley Pryor, and 3.83 for Yellow Oronoko. In different grades of manufacturing tobacco, the nicotine content ranged from 1.54 per cent in high grade, bright, flue-cured tobacco to 5.56 per cent in English shipping. Among these grades the light tobacco was found to contain the lowest and the dark tobacco the highest percentage of nicotine.

Results obtained at the North Carolina Station[2] indicated that the nicotine, when the plant is mature, is found mainly in the leaves. Analyses of typical tobaccos grown in the United States show that in the samples tested the nicotine in the water free substance of the leaf ranged from 1.45 per cent in Pennsylvania Seed Leaf to 5.53 per cent in German Spinning Leaf, grown in Tennessee. The author associates a coarse, rank growth with a comparatively large amount of nico-

[1] Virginia Station Bul. 52. [2] North Carolina Station Bul. 122.

tine, and states that the percentage of nicotine is materially increased by the use of large quantities of nitrogenous fertilizers. Nicotine was not found to be an important factor in affecting the burning quality of tobacco. It is stated that the nicotine content of tobacco leaf is materially reduced in the process of fermentation, but no figures are given to show to what extent this reduction takes place.

The Connecticut State Station [1] found that the nicotine content was reduced by fermentation from 2.5 to 1.62 per cent in upper leaves, from .77 to .44 per cent in short seconds, and from 1.25 to 1.05 per cent in first-wrapper leaves.

ARSENIC IN SPRAYED TOBACCO.

The presence of arsenic in tobacco sprayed with arsenites was studied by the Kentucky Station to determine whether or not enough arsenic was left on the leaves of the plant to injuriously affect the health of the consumer.

In 1894 [2] tobacco was sprayed with Paris green and London purple solution. It is estimated that individual plants sprayed once with Paris green received 1.0329 grains of arsenic, those sprayed twice, 2.00456 grains, and plants sprayed with London purple, 1.8957 grains. The chemical examination of the sprayed tobacco showed that whether the original amount of arsenate was large or small only a comparatively small portion remained on the plant at the time of harvesting. The largest amount of arsenic obtained in these investigations was 0.329 grain per pound of tobacco, or only about 4 per cent of the arsenic originally applied. The plants sprayed but once retained about 1.8 per cent of the amount left by spraying, and those sprayed with London purple about 3.2 per cent.

In 1895 [3] the inquiry into this subject was continued in connection with another experiment. Plants were sprayed 1 to 8 times, from July 3 to August 22, with a solution of one-fourth pound of Paris green to 40 gallons of water, and the amounts of arsenic which they retained at cutting time were determined. The amount of Paris green applied varied with the number of applications, ranging from 0.1 to 0.8739 ounce per row. Plants sprayed once or twice showed only a trace of arsenic, and since some arsenic was found in tobacco which had not been sprayed it is concluded that practically all the arsenic left by spraying was gone when the plants were cut on September 4. A number of plants which had been sprayed only once, but were sprayed again on September 5 and cut as soon as they were dry, contained 0.0139 per cent of arsenic, evidently obtained from the last spraying. The tobacco which was sprayed 8 times contained 0.0093 per cent of

[1] Connecticut State Station Report 1892. [2] Kentucky Station Bul. No. 53.
[3] Ibid. No. 63.

arsenious oxid. These results are considered as showing the extent to which arsenic is removed when the plants are not harvested until some time has elapsed after spraying. It is further pointed out that applications of Paris green shortly before harvesting should be avoided.

"While the question * * * is still open to discussion * * * it may be confidently asserted that the amount of arsenic contained in the small fraction of a pound which a man would consume in a day, even if taken at one dose instead of being distributed throughout twelve hours, would produce no harmful effect."

INSECTS AFFECTING TOBACCO.

Most of the common insect pests which are troublesome to tobacco culture have been studied by the stations. The Kentucky Station has given attention to the prevention of depredations by the tobacco worm, the bud worm, the flea beetle, the spined tobacco bug, and grasshoppers. The spined tobacco bug,[1] which causes the plants to wilt suddenly and thus checks their growth, was noticed to attack tobacco plants grown next to a pasture, whence the bugs are believed to have come. As a remedy, removing the bugs from the wilted plants is suggested, and as a preventive measure, not to allow weeds, especially thistles and mullein, which are very attractive to these insects, to grow near tobacco fields is recommended.

It was also observed that when corn becomes inedible to the corn worm this insect attacks tobacco grown in adjoining fields. To obviate this trouble it is advised not to grow early corn near tobacco.

It was further noticed that grasshoppers[2] sometimes do damage to tobacco when grass or other close-growing crops upon which they have fed are removed. The use of Paris green was found to destroy them, but not before some damage had been done. The author suggests that all unnecessary growth likely to harbor these pests near the fields should be kept down.

Several specimens of bud worms were studied.[3] They left the tobacco plants and went into the ground August 10, and the adult moths came out about two weeks later. It was observed that the specimens under observation gnawed holes in the young leaves at the center of the plant before they were unfolded. A thorough application of Paris green is considered a suitable remedy.

For the flea beetle, dusting with pyrethrum or spraying with a solution of this powder is regarded as preferable to the use of lime water, which deteriorates the quality of the leaves by the deposition of lime.

For the prevention of damage by the tobacco worm,[4] the ordinary practice of putting sirup poisoned with cobalt, arsenic, or strychnine

[1] Kentucky Station Bul. No. 66. [2] Ibid. No. 63. [3] Ibid. No. 49. [4] Ibid. No. 40.

into the blossoms of jimpson weeds to poison the moths is worthy of recommendation. It is advised that the late brood of worms which feeds almost exclusively on tomato plants be destroyed by the use of poisons or kerosene emulsion.

Young tobacco worms[1] were observed on tobacco plants early in July, August, and September. Of these different broods the one appearing in early August is regarded as the most injurious, but the brood appearing in July is not without its bad effects. The station concludes from its experience that the best remedial measure is to spray with a solution of 1 pound of Paris green in 120 to 160 gallons of water, making the application as soon as the young worms appear. The author states that spraying more than three times is unnecessary when the times of making the application are well chosen.

In 1896[2] the tobacco worm was very abundant, and further observations were made by the station entomologist. The average persistence after treatment of the young worms was 4.43 days and of the large worms 12.33 days. The average duration of all lots of worms treated with a solution of 1 pound of Paris green in 40 gallons of water was four days, and when a mixture of 1 pound of Paris green in 150 gallons of water was used, 14.17 days. The weaker solutions were found sufficiently strong for the destruction of the young worms, but in destroying the large worms the strong solution proved the most effective.

The Maryland Station[3] found that a poisoned mash, consisting of 50 pounds of wheat bran, 2 quarts of molasses, 1 pound of paris green and water, dropped from three to five days before planting, near the places where the plants are to be set, prevented the cutworms from injuring tobacco fields.

In testing tobacco seed the Florida Station found that apparent damping-off of the seedlings was due to nematode attacks.[4] The seedlings were grown in sand which had been kept air dry for ten months prior to sowing the seed. The injury was produced by the worms from the outside at any point on the plant. When attacked the points of irritation became enlarged, the development of the seedling was arrested, and the final result was the destruction of the young plant. To prevent the trouble, the author advised growing tobacco seed on uninfested soils, and states that old land is apt to be infested, and that this may be ascertained only by observation of the trouble in previously grown crops.

TOBACCO AS AN INSECTICIDE.

As an insecticide tobacco has a wide application and its use for this purpose, it is safe to say, has been tested by every experiment station

[1] Kentucky Station Bul. No. 63.
[2] Ibid. No. 66.
[3] Maryland Station Bul. No. 55.
[4] Florida Station Bul. No. 24.

in the country. A brief summary of the methods of application and the results obtained at a number of stations are here given.

Tobacco decoction was used with effect by the New Jersey Experiment Station[1] against attacks of flea beetles on potatoes, plant lice on rose bushes and chrysanthemums, the wheat louse, the larvæ of the rose tortricid, and the rose slug, but its effects were not satisfactory when used for the larvæ of the elm leaf-beetle, hairy caterpillar, rose chafer, and striped beetle. Coarsely ground tobacco dust was ineffective when applied on dry plants but had some effect on moist plants. Finely ground tobacco dust was much more effective. The addition of carbolic acid to tobacco powders increased their efficiency fully 50 per cent. The author states that tobacco dust put into the soil was successfully used in 1890 by Dr. E. F. Smith as a remedy for the peach louse; either tobacco decoction or tobacco dust was ineffectual as a remedy for the rose chafer.[2] It was found that the horn fly[3] succumbed very readily when brought into contact with tobacco powder.

The Ohio Station found that dusting lettuce, roses, and other plants grown in greenhouses with tobacco powder destroyed the plant lice[4] with which they were infested.

At the Michigan Station[5] tobacco decoction was successfully used to free currants, gooseberries, and apple trees from plant lice and cherry, plum, and pear trees from slugs. It also proved effective against striped flea beetles and cucumber flea beetles.[6]

Experiments conducted at the Missouri Experiment Station showed that applications of tobacco dust were effective in preventing depredations by the woolly aphis of the apple or apple-root plant louse.[7]

TOBACCO SOILS.

A comparative study of tobacco soils is reported by the Pennsylvania Station. The investigations were made in 1894 on Pennsylvania soils from Donegal and Lititz, in Lancaster County, and Rocky Spring, Franklin County; and also on soils from the best wrapper-leaf districts of New England and North Carolina. The best tobacco soil from Granville County, N. C., the soil of the "plains" land at East Hartford, Conn., and the soil from Poquonock, Conn., were composed chiefly of medium fine and very fine sand. Tobacco soil from Granville County, N. C., and the soil from Podunk, Conn., Hatfield, Mass., and Rocky Spring, Pa., consisted mainly of very fine sand and silt, the Rocky Spring soil being very largely composed of silt and the others of fine sand; and the tobacco soils from Donegal and Lititz

[1] New Jersey Station Bul. No. 75.
[2] Ibid. No. 82.
[3] New Jersey Station Rpt., 1889.
[4] Ohio Station Bul. No. 2, vol. 4.
[5] Michigan Station Bul. No. 118.
[6] Michigan Station Bul. No. 58 and Rept., 1890.
[7] Missouri Station Bul. No. 35.

were composed mainly of very fine silt and clay. The mean soil temperature during the growing season at Rocky Spring was 76.1°, and at East Hartford and Poquonock, 77.4°; but at Rocky Spring the difference between day and night temperatures was smaller than at the other places.

The moisture content of tobacco soils from a number of localities, including those already mentioned, was determined and its variation during the season observed. The average percentage of moisture determined in the various soils was as follows: Soils from South Deerfield and Hatfield, Mass., 19.5 to 22 per cent; from East Hartford, Conn., South Granby, N. Y., and Rocky Spring and Donegal, Pa., 14.5 to 17 per cent; from Bloomfield and Windsor, Conn., and Saxon and Cana, N. C., 9.5 to 11.5 per cent; and soil from Poquonock, Conn., 7.5 per cent. The range of variation of moisture content during the season in Rocky Spring soil was 11 per cent; in soils from Donegal, South Deerfield, South Granby, Cana, and Bloomfield, 3.5 to 5.5 per cent; in Hatfield, Mass., and East Hartford and Windsor, Conn., soils, 2 to 3 per cent; and in soils from Poquonock, Conn., and Saxon, N. C., 0.5 to 1 per cent. It is concluded that the Rocky Spring soil is most subject to the influence of short droughts. The water-holding capacity of the dry subsoil from Donegal was 52 per cent, and of that from Rocky Spring 45 per cent. The soil at Donegal was found capable of absorbing 3.25 per cent of moisture from the atmosphere, and the soil at Rocky Spring 3.09 per cent. In general the soils from Lancaster County, Pa., were found to be heavier and somewhat more moist than the best wrapper-leaf soils of other districts, and, so far as examined, warmer and more equable in temperature. The investigations further pointed out that these soils rank well in fertility and did not contain injurious constituents in excessive proportion.

Tobacco was grown on different kinds of soils by the Louisiana Experiment Station.[1] It is concluded from the results obtained on old worn lands and pine thickets in northern Louisiana that such soil is well adapted to the culture of the yellow or bright leaf varieties of tobacco.

In 1894 White Burley tobacco grown on the red heavier sandy soil of northern Louisiana gave as good or even better results than when grown on the lighter soils, and Oronoco, a bright variety, cured as brightly when grown on the one soil as when grown on the other. Cigar leaf varieties also grew better on this type of soil than on the lighter sandy soils.[2] It was found that the lighter the land the more readily tobacco cured brightly.

The North Carolina Station found that the light sandy soil of Granville County of that State produced a tobacco with a large percentage

[1] Louisiana Stations Bul. 20. [2] Ibid. 33.

of carbohydrates, especially starch and glucose. The soil of this region contains a very small percentage of available mineral matter and seems to be especially adapted to the production of yellow tobacco.

Below are given some of the results of soil analyses made by different stations in connection with their investigations on tobacco:

Results of tobacco soil analyses.

	Soils from—				
	Colorado. *a*	Virginia. *b*	North Carolina. *c*	Florida. *d*	Cuba. *e*
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Moisture	2.78	0.577	0.312	1.000	14.200
Organic matter	4.53	2.982	*f*1.510	.950	12.300
Insoluble matter	72.71	.....	95.642	97.000	82.300
Phosphoric acid	.21	.019	.016	.053	1.600
Potash	.41	.019	.161	.018	.160
Nitrogen	.02	.090	.....	.028	.320
Lime	.70	.076	.240	.130	7.600
Magnesia	.85	.036	.047	.008	.170
Iron oxid	3.37	1.550	.326	.790	29.400
Alumina	4.29		1.038	.....	.....
Soda	.71	.088	.109	.030	.084

a Colorado Station Bul. No. 10.
b Virginia Station Bul. No. 12.
c North Carolina Station Bul. No. 90a.
d Florida Station Bul. No. 19.
e Florida Station Bul. No. 19.
f Reported as volatile matter.

The Division of Soils has made quite an extensive study of the principal tobacco soils of the United States and has issued several bulletins thereon.[1] It will be unnecessary to summarize the results here as the publications can readily be obtained.

CONCLUSIONS.

Having thus reviewed the work of the experiment stations, it will be well to outline clearly the general purpose of tobacco investigations in order to understand fully the most important lines to be developed.

One of the questions most frequently asked is the possibility of extending the culture of tobacco to new areas. While tobacco is confined as at present to comparatively small areas, and while it continues to be one of the "money crops" of the farm, there will naturally be a widespread desire to extend the cultivation to new localities. This is one of the most difficult things to advise about, as so little is known about the influence of climate and other conditions upon the quality of the leaf.

The tobacco industry is so highly specialized that a nondescript tobacco is no longer needed and brings only a very low price. The qualities of the tobacco leaf, including the size, shape, and thickness of the leaf, the flavor and aroma, the grain and general style, are so delicate, so easily influenced, and as yet so difficult to control that it is impossible to say beforehand what qualities a leaf would have raised

[1] Bul. No. 5, Texture of Some Important Soil Formations. Bul. No. 11, Tobacco Soils of the United States. Farmers' Bul. No. 83, Tobacco Soils.

CHEMICAL COMPOSITION OF THE TOBACCO PLANT.

The chemical composition of the tobacco plant has been studied by the stations from various points of view, The different parts of the plant have been analyzed to determine the amount of plant food contained in them. Studies have been made to ascertain the effect of curing and fermenting upon the composition of the leaf and stalk; and the composition of the refuse, such as tobacco dust and tobacco stems, has been determined to show its value as a fertilizing material. A number of analyses of tobacco ash are also reported. The most important results are here briefly summarized.

At the Colorado Station,[1] the analyses of the ash of a number of varieties of tobacco showed that the composition of the samples grown was similar to the average composition of tobaccos produced in Connecticut and elsewhere. One qualitative test for acids in the leaf was made, and acetic, pectic, citric, malic, and oxalic acids were found. The leaves also contained considerable quantities of resinous and fatty substances. The ash of Havana tobacco grown on poor soil was found to contain more than twice as much silica but considerably less lime, potash, and carbon dioxid than the same variety grown on rich soil.

A study of the occurrence of nitrates in tobacco at different stages of growth made at the North Carolina Station[2] pointed out that the nitrates are confined almost entirely to the stalk and stems in the young plants. During the later growth of the plant practically no nitrates were found. Samples of tobacco stems from different sources were analyzed by the station and compared. Stems of cigar tobacco from Missouri, Connecticut, and Ohio and stems of export tobacco from Virginia contained 0.83, 0.72, 0.60, and 0.54 per cent of nitrates, respectively, while stems of cigarette tobacco from North Carolina contained 0.15 per cent. No nitrates were found in North Carolina stems of chewing tobacco or in the dust from the North Carolina product. In general the total nitrogen content was smaller in North Carolina tobacco stems than in those obtained from tobacco grown in the other States mentioned. Whole leaf of North Carolina bright tobacco cured by the leaf-curing process contained 16.23 per cent of potash, while the same kind of tobacco cured by the stalk-curing process contained 21.81 per cent. Other variations in the composition of tobacco resulted from the two methods of curing, but it is believed all these differences in the chemical composition are due mainly to the manner and time of harvesting, and that in general the composition of tobacco cured by similar methods is not materially affected by separating the leaf from the stem before curing if the condition of the tobacco is the same when put into the barn.

[1] Colorado Station Bul. No. 10. [2] North Carolina Station Bul. No. 90a.

Analyses of parts of the tobacco plant at different stages of growth were made at the Virginia Station in 1894.[1] Nearly one-half of the ash of young plants consisted of potash, amounting to three times the content of lime. The percentage of ash in the leaf at four different stages was about the same, increasing slightly from topping until cured. The nitrogen content was nearly 1 per cent higher at the time of topping than when the leaf was cured, while the percentage of phosphoric acid showed very little change, being a little higher when the plants were topped than when cured. The potash was highest at topping and lowest when the leaf was cured, while the reverse was true of lime. Soda was found to be a little lower at topping than at any other time. The percentage of magnesia, sulphuric acid, and chlorin was found slightly increased in the cured state. The plants taken from the plant bed contained, in an air-dried condition, nearly 3 per cent of nitrogen, nearly 1 per cent of phosphoric acid, over 8 per cent of potash, and about 2.5 per cent of lime. Results further show that at the time of topping the whole plant contained about 3 per cent of nitrogen, one-third of 1 per cent of phosphoric acid, about 4 per cent of potash, and over 2 per cent of lime. At the time of cutting it contained nearly 3 per cent of nitrogen, one-third of 1 per cent of phosphoric acid, and more than 3½ per cent of lime.

A series of analyses of different grades of manufacturing tobacco from Virginia, West Virginia, and North Carolina were made by the Virginia Station and reported about the same time as the work described above.[2] The results are of interest in showing to what extent the chemical composition of grades of manufacturing tobacco is subject to variations. The samples analyzed were taken from the crops of 1890 and 1891. The question of varieties was not considered. In the sun-cured tobacco the crop of 1891 in one county contained about one and one-half times as much potash, nearly twice as much sulphuric acid, and one-sixteenth more lime than that of 1890. High-grade bright flue-cured and low-grade bright flue-cured tobacco grown in different counties in different years were found to contain about the same amount of ash, but the low-grade tobacco contained about twice as much nitrogen, phosphoric acid, potash, magnesia, and sulphuric acid as the high grade. The chlorin content of the grades was about the same, but the amount of soda and insoluble matter in the high grade was about six times as much as in the low grade. In one county the potash in the crop of 1891 was about one and one-half times that of 1890, the magnesia and chlorin nearly twice as much, and the insoluble matter about one-fifth as much. The analyses of manufacturing tobacco grown in Virginia agreed very well in their ash content, except in one county, where it was much lower. The potash did not agree

[1] Virginia Station Bul. No. 50. [2] Ibid., No. 51.

and desirable flavor that is characteristic of the better grades of Cuban tobacco. This work also will involve radical departures from the present methods of cultivation and of fermentation, but even with the best that can be done in this line it is probable that much will yet remain to be done by the plant physiologist in the improvement, by selection and breeding, of the aroma.

So far as present experience goes, it would appear that the investigations in Connecticut should be with the idea of producing desirable wrapper leaf; in Pennsylvania and Ohio the conditions seem to be peculiarly adapted to the production of a desirable filler; in Florida, wrapper leaf alone should be considered, while so far the tobacco districts of Texas have given evidence that the conditions are best adapted to the production of a rich filler leaf.

The problems connected with the cigar tobacco industry are very marked and sharply defined in the preceding paragraphs. The cigar tobaccos of this country do not come up to the present requirements of the cigar trade. We have very satisfactory standards in the Sumatra tobacco for the cigar wrappers and in the Cuban tobacco for cigar fillers.

In the matter of the manufacturing and export types, the lines of investigation are not so clear nor so well defined. The cigarette tobacco of Virginia, North and South Carolina, and East Tennessee are admirably adapted to their purpose. They are themselves the standard for this particular class of leaf. They are not only adapted to domestic use for cigarettes and plug wrappers, but they are exported in increasing quantities to many foreign countries. The average price of the bright yellow and the mahogany leaves are lower than they were a few years ago. The fine, bright wrapper leaf sells for from 25 to 40 cents per pound and the mahogany wrappers for 25 cents per pound. Fancy leaves still sell for from 60 cents to $1 per pound. A specimen of 10 pounds of fancy, bright tobacco was recently purchased by a gentleman in the warehouse at Raleigh, for which he paid $1 per pound, the tobacco to be used for the tobacco exhibit of the Paris Exposition. This tobacco was really a very fine specimen, and the price paid was unquestionably the true commercial value of the leaf. The low price of the inferior grades is due to the fact that there is so much really inferior bright and mahogany tobacco placed upon the market. The effort on the part of the experiment stations should be to investigate the cause of this and to raise the standard of quality of the average crop. The very marked improvement in the manipulation and production of this cigarette tobacco in recent years leaves no reason to doubt but that results can be obtained in generally improved methods for the improvement of the average crop of bright and mahogany tobaccos grown in this country.

Burley leaf and the various export tobaccos seem well adapted to the purpose for which they are now used. There is no need of a radical change, as in the case of the cigar tobaccos, but there is need of a general improvement of the average crop. In the Burley tobacco, for example, the lugs and two grades of tobacco inferior to this form a large proportion of the crop, and bring low prices. The object should be to obtain more of the better grades of leaf from the stalk. The same thing is true in regard to the export tobaccos. The French C sells for about 3 or 4 cents per pound. This appears to be satisfactory to the French Government for a certain class of consumers. It should not be satisfactory to our farmers to produce such a low grade of leaf.

The Austrian A brings from 15 to 16 cents per pound, while Great Britain and Australia take tobaccos which bring from 20 to 30 cents per pound.

To a certain extent the grading is done by the growers—that is, if the leaf gives promise of being adapted to the English market it is harvested green or underripe and is heavily smoked, as these are requisites of the English market for certain classes of tobacco. If it is inclined to be light and trashy it is gathered overripe for the French trade. As a rule, however, the tobacco is graded by the packers and dealers, who sort it out in strict accordance with the character and quality of the leaf. If they assign a sample to the French C it is because it is of poor quality and is not adapted to the Australian or English markets. As a general rule the high-priced tobaccos are manufactured in this country for domestic use, and the lower-priced goods are sent abroad. Still, however, more and more of our high-priced tobaccos are being sent abroad.

In addition to these broad and important economic lines of investigation, there are many problems connected with the chemical composition of the leaf, the chemical substances produced in the leaf, the relation of nicotine to the flavor and aroma, the changes in the curing and fermentation, the influence of soil, of seed, of climatic conditions, of cultivation and of handling, which are of great importance as aids in changing the style or character of the leaf to conform to the market demands.

The chief features of the cigar wrapper are the style of the leaf, the size, uniformity of color, and the absence of any pronounced flavor or aroma. The chief features of a filler leaf for cigars are flavor and aroma. In the fine, bright and mahogany tobaccos it is mainly the color which determines the price. In the manufacturing and export types the quality, size, and shape of the leaf and color determine the market and the use to which they are suited.

These are broad economic lines suggested for investigations, which it is very desirable that some of the stations should take up. The

question of the proper method of preparing the seed bed, the question of the effect of fertilizers, the burn, etc., should all be subordinated to the one great problem of presenting the leaf required by the cigar manufacturers. These questions will naturally be considered in working out the broad problems, but they should not be given the first place and be considered complete in themselves.

O

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
OFFICE OF THE SECRETARY,
Washington, D. C., February 1, 1900.

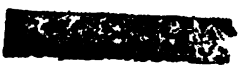
MR. PRESIDENT: I have the honor to transmit a report of this Department upon the field operations of the Division of Soils during the year 1899. It covers not only the most important work of this division, but, is, in my opinion, regarded in the light of the possible results of the information which has been secured thereby, the most important work of this character ever undertaken in any country. It consists of an introduction by Prof. Milton Whitney, the chief of the division, and special reports on the various lines of field work by the scientific assistants of that division, in cooperation in some instances with educational institutions in various parts of the country. The report covers, all together, a soil survey of an area of not less than 720,000 acres, scattered throughout the following regions: New Mexico, Utah, Colorado, and Connecticut. These accounts of soil surveys are followed by some valuable discussions on "the application of the theory of solutions to the study of soils," "some necessary modifications in method of mechanical analysis as applied to alkali soils," and "salts as influencing the rate of evaporation from soils."

It need hardly be said that it was found quite impossible to restrict this report within the limits of a hundred octavo pages, and consequently, under the operations of section 89, chapter 23, Volume XXVIII, of the Statutes at Large, 1895, the Secretary of Agriculture has no authority to secure the printing of more than 1,000 copies, a number which would be entirely inadequate to supply our exchanges, our agricultural colleges and experiment stations, and the divisional list of the Division of Soils, to say nothing of any miscellaneous demand. In this case, moreover, the Department, in my opinion, is bound to supply copies of the report to the very large number of persons who have rendered efficient aid to our surveyors in their field work.

Under these circumstances and in view of the great importance of the subject covered, I have the honor to recommend that it be transmitted to Congress, together with the maps, illustrations, and diagrams accompanying, to be printed by order of that body, and I further recommend that not less than 10,000 copies be printed for the use of this Department, in addition to such number as Congress may order for the use of its members.

I have the honor to remain, Mr. President, very respectfully,

JAMES WILSON,
Secretary.



LETTER OF SUBMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
DIVISION OF SOILS,
Washington, D. C., January 29, 1900.

SIR: I have the honor to present herewith a report on the field operations of the Division of Soils for 1899. This is, without doubt, the most important work that has been undertaken by the division since its organization. The report is illustrated by a number of photographs and diagrams showing the character of the country and the specific characteristics of the soil, and by accompanying maps showing the distribution of the soils, alkali, and seepage waters. That portion of the report prepared by Dr. Cameron relates to work undertaken in cooperation with the Division of Chemistry, and has been read and approved by Dr. Wiley. The soil work is of great interest and is very widespread in its application. A small edition would be entirely inadequate to supply the exchange list of the Department and the ordinary mailing list of this division, besides the very large number of persons who, having aided and cooperated with the division in its work, are entitled to a copy when published. I therefore have the honor to recommend that not less than 10,000 copies of this report be printed for the use of this Department.

Respectfully,

MILTON WHITNEY.
Chief of Division.

Hon. JAMES WILSON,
Secretary of Agriculture.

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FIELD OPERATIONS OF THE DIVISION OF SOILS IN 1899.

By MILTON WHITNEY, Chief of Division.

PROGRESS AND COST OF THE SOIL SURVEY.

During the season of 1899 three well-organized parties were in the field for from six to eight months each, equipped according to the most modern methods for surveying, investigation, and mapping the soils of several important agricultural districts. Eleven hundred and twenty-five square miles, or about 720,000 acres, have been surveyed and mapped on a scale of 1 inch to the mile. The following table shows the areas which have been surveyed, the rate per day, and the actual cost of the field work per square mile:

	Area.	Rate per day.	Cost per square mile.
	Square miles.	*Square miles.*	
Cecil County, Md	375	5	$1.70
Connecticut Valley	400	4.5	2.00
Salt Lake Valley, Utah	250	2	[a]6.00
Pecos Valley, New Mexico	100	1.1	12.00
Total	1,125		

[a] The actual cost of the work to the Division of Soils was $4 per square mile, the Utah Experiment Station cooperating and paying the equivalent of $2 per square mile.

The difference in the cost of the work is due to the more complex problems presented in the arid regions of the West, as will be explained, as well as to the greater distance from Washington and the consequent greater cost of transportation. The cost per square mile given in the table includes the salaries of the men while actually in the field, together with their transportation and subsistence expenses. Taking into account the annual salaries of the men assigned to the soil survey, together with all expenses directly chargeable to the work in the field, the amount expended during the calendar year 1899 for such work amounted to 27.8 per cent of the total appropriation for the Division of Soils. The laboratories, contributing largely to the efficiency and support of the soil surveys, consumed 22.5 per cent of the total appropriation; the administrative expenses—including rent of building, express, gas, and the fitting up of an additional laboratory room—amounted to 40.5 per cent of the total appropriation.

For administrative purposes in the Division of Soils the United States has been divided into the eastern and western districts, with the Mississippi River as the dividing line. Mr. C. W. Dorsey has general charge of the soil survey of the eastern district, and Mr. Thos. H. Means of the western district. In the western district the work has so far been confined to irrigation districts, and has included, besides the mapping of the soils, the investigation and mapping of the alkali conditions and of the depth to standing water. Such maps, showing the exact distribution and condition of the soil, serve as a basis for the improvement or reclamation of alkali lands by underdrainage or by other means for removing the excessive accumulation of alkali and seepage waters. They also show the source of possible future damage, and by their aid suitable preventive measures can be taken to provide against such losses as have occurred in the past.

In localities where sodium carbonate or black alkali prevails a separate map is made, showing the distribution and relative intensity of this substance.

The areas which have been surveyed this year are not at all simple in their conditions, and represent perhaps as great a variety of soils and soil conditions as will ever be encountered in a season's work. As a rule, the soils of the West are more uniform over small areas than they are in the Atlantic Coast States, but on account of the greater number of conditions to be taken under consideration and investigated, in the surveying and mapping, and the necessarily more complex field methods, the work is much slower.

The expense of the work in Cecil County, Md., and in the Connecticut Valley averages less than $2 per square mile, including the salaries of the men while in the field and the transportation and subsistence expenses. This is considered very satisfactory. The parties consisted in each case of two men working together, each party having a horse and wagon.

The relatively small area per day covered in the Pecos Valley, New Mexico, and the apparently excessive cost ($12 per square mile) is accounted for by the newness of the work, the fact that two experienced men were assigned to this work—for their mutual training and for the final perfecting of the methods—and to the further fact that considerable detail work was done in the study of the conditions and methods to be used under such conditions—necessary work which will not have to be done again.

The expenses of the work in Salt Lake Valley, Utah ($6 per square mile), are considered fairly satisfactory, although it will doubtless be possible to materially increase the rate per day, and thus lessen the cost per square mile as the men become better acquainted with the methods of surveying and with the causes and conditions of the alkali soils. With the experience of this season such an area as this could probably be surveyed now at a cost of about $4 per square mile.

It must be remembered that the estimation of the cost of such work in new localities is a mere approximation, as the expense depends largely upon the complexity of the conditions in the locality to be surveyed. In each of these districts in the West the field parties consisted of two men, with a horse and wagon for carrying the field equipment, without a camping outfit, as the work done was in rather closely settled districts.

It has been the intention to have an experienced man in charge of each field party, with a student assistant or an intelligent laborer to assist in the work. So far as possible advantage is taken of these opportunities to train men for the more responsible positions devolving upon directors of field parties. Such educational work is a very essential and important part of the work of the division, as it is impossible to obtain men already trained and fitted for this field work.

COOPERATION WITH STATE ORGANIZATIONS.

Wherever possible it has been the policy of the division to work in close cooperation with the State experiment stations, the State geological surveys, boards of agriculture, or other local institutions. This cooperation, so far as it has been carried, has proved mutually satisfactory and beneficial to the local institutions and to this division. In a general way it relieves the local institutions of all responsibility of the direction of the work and the preparation of the material, while the expense to them is very much less in every case than if they had to employ competent soil experts, even if such experts could be obtained, which is questionable. On the other hand, this cooperation enables the Division of Soils to very materially widen its sphere of field work, and gives the division a desirable connection with local institutions, in touch with the people actually interested in the work.

Owing to the difference in the character of the work in the Eastern and Western districts the basis of the cooperation with State institutions has been essentially different. The arrangements under which the work has been done during the present season may be briefly stated.

The soil survey of the Connecticut Valley was carried on by the Division of Soils, independently of any other organization, under the authority of Congress to investigate and map the tobacco soils of the United States. This work was in charge of Mr. C. W. Dorsey, with Mr. J. A. Bonsteel, of the Johns Hopkins University, as temporary assistant. A detailed soil map, with accompanying text describing the different soils, is given in the latter part of this bulletin.

Under authority from the Secretary of Agriculture an agreement was entered into with the Maryland geological survey, Dr. William B. Clark, director, to survey and map the soils of Maryland at the rate of one county each season, which is the present rate at which the topographic base maps and the geological data are being prepared. Under the terms of this agreement the Division of Soils assumes the

entire responsibility for the details of the soil survey, together with the preparation of the manuscript map, with a brief description of the soils. This material is turned over to the State survey, the Department reserving the prior right of publication, to be published with such additional data as they may wish to include in their final report. The publication of the map by the Division of Soils, with brief notes as to the soil classification, is not expected to conflict in any way with the more elaborate State publication for local distribution. Under the terms of the agreement the Maryland Geological Survey pays the traveling and subsistence expenses of the field party. This amounted in the present case to about $400, or approximately $1 per square mile. The area selected by the director of the State survey was Cecil County. While the soil survey has been completed and the manuscript map prepared, the publication will be delayed a year, awaiting the engraving and publication of the topographic base sheet, which has just been completed in manuscript.

The soil survey of the Pecos Valley, New Mexico, was carried on by Thomas H. Means and Frank D. Gardner, of this division. The entire expense was paid by the Division of Soils, and there was no official cooperation with any other organization. The New Mexico Experiment Station, however, authorized Prof. J. D. Tinsley to accompany the field party for the purpose of studying our methods. Professor Tinsley spent about a month helping with the work in the district around Roswell.

The work in Utah was done in cooperation with the Utah Experiment Station, Prof. Luther Foster, director. The terms of the cooperation were that the Division of Soils would send an expert to take charge of a field party, pay his salary, traveling and subsistence expenses, and be responsible for the preparation of maps and reports which would treat fully of the conditions of the area. The Utah Experiment Station would furnish an assistant and pay his salary and traveling and subsistence expenses while in the field. The expense to the experiment station amounted to about $2 per square mile.

In this alkali work, unlike the soil work in the eastern district, the reports have to treat very fully of all the conditions, and the same report will therefore serve for and be credited to the Division of Soils and to the Utah Experiment Station.

The director of the Utah Experiment Station designated Mr. John Stewart as an assistant in the Utah work, Mr. Frank D. Gardner having direct charge of the field party. The results of the field work are briefly referred to in this paper and are set forth in detail in the accompanying papers and maps.

In the progress of the field work this year, and particularly in the review of the work in the preparation of the reports and maps, many valuable modifications have been suggested in our methods which it is believed will greatly simplify the work and increase the efficiency

of the field parties. One feature which has been brought out clearly is the fact that the field methods are now practically independent of the laboratory methods. The soils and alkali salts are classified and mapped in the field. The maps themselves are actually prepared in the field in such form that they can be turned over to the lithographer after suitable titles and legends are prepared. This refers to the soil, the alkali, the black alkali, and the underground water maps. Much of the laborious work of calculating the actual salt content has been saved, as limiting values only are shown upon the map, and it is hardly considered advisable to publish the figures of actual salt determinations in tables which few, if any, would read.

The laboratory work connected with the survey has likewise been reduced to a minimum. The chemical and physical laboratories are used now simply to explain the character of the soils which have formed the basis of the classification. For example, the physical differences between the Hartford sandy loam and the Connecticut meadows are clearly brought out in the mechanical analyses. On the other hand, the differences between the Pecos gypsum soil and the Pecos sandy loam are apparent not only from the mechanical analysis, but also through the chemical analysis. These conditions, however, are so marked in each case and so apparent that the soil areas can be accurately mapped, even without the results of the physical and chemical examinations. This matter of the field methods will be referred to more at length on a subsequent page.

The alkali and underground water maps show the conditions at the time of the survey. At different seasons of the year and especially under different weather conditions the soil conditions may be somewhat different; but as the examinations are usually made during the growing season the conditions shown may be taken to represent fairly well the actual conditions of growth.

OPERATIONS IN THE PECOS VALLEY, NEW MEXICO.

Reports have come in to this Department from time to time for several years from the Pecos Valley of root-rot disease affecting fruit trees, grapevines, sugar beets, and alfalfa—the trees and vines much more seriously than the other crops. Truck crops seem to have largely failed in the valley, while the yield from alfalfa, which seems to be the crop best adapted to the conditions there, is only about 5 tons to the acre in 4 cuttings. In Montana it is from 6 to 7 tons in 3 cuttings.

In view of these serious reports, the importance of the locality, and the expressed willingness of the people to benefit by the results of the investigations, it was decided to send an expedition to investigate and map the soils and soil conditions of a portion of the valley. Accordingly, Thomas H. Means and Frank D. Gardner, of this division, were sent out and spent two months at Carlsbad and one month at Roswell. I personally inspected the work during the progress of the investigations. The detailed account of this work is given in an accompanying

paper, and is illustrated by a series of maps, diagrams, and photographs.

It was found in the Carlsbad area that fruit, truck, and grapes were almost entire failures; that the sugar beets and alfalfa gave relatively small yields and were affected with root-rot over certain areas. There are many abandoned farms and large areas over which the conditions generally are not satisfactory.

One reason that fruit has not been successful is the liability of the occurrence of late spring frosts which destroy the buds after they have started. The root-rot disease, which has been so destructive in the valley, is unquestionably largely due to the condition of the irrigation water during part of the year and over some sections of the valley. The salt content of the water is so high that it is near the limit of endurance for crops. The occurrence of gypsum soils and of seepage waters also accounts for much of the trouble. These matters will be briefly summarized here.

In regard to the natural conditions which have had to be contended with, it may be well to state that the settlers were not well prepared to meet these new and untried conditions. In settling the valley the land company attracted a large number of settlers from abroad as well as from various parts of this country. Many of the persons locating in the valley were entirely unacquainted with the exact conditions prevailing in the Pecos Valley, and, indeed, unacquainted with the methods of irrigation in general. The settlers paid the company so much an acre for the use of the water and unfortunately felt that the more they used the more of value they were getting from the company. From these various reasons there was undoubtedly some bad management which resulted occasionally not only in the financial ruin of the owner, but seriously damaged by seepage waters his own or his neighbor's land as a result of over-irrigation.

At the present time much of the ownership of the land is vested in the water company and rented to irresponsible Mexican settlers who move from place to place and have not much interest in using the necessary means for preventing damage to the land, and who are quite willing to move if crop failures result from their own mismanagement or from any other cause. This social condition must be taken into account in any plan for the improvement and reclamation of the lands. A Mexican settler is not likely to invest money in underdrainage or in any other method of preserving or reclaiming the land and, owing to the uncertain tenure of these tenants, the company naturally hesitates before putting in any expensive improvement of this kind. The conditions, therefore, are not as satisfactory as might be wished for the most efficient work in the reclamation and general improvement of the lands.

Next to the ownership of the land and the labor questions, the most important cause of the trouble in the larger portion of the Pecos Valley

s the high salt content of the irrigation water, especially in certain easons.

At Roswell the principal water supply contains about 76 parts of sol- ible matter in 100,000 parts of water. At Hagerman this is increased o about 200 parts; at Carlsbad to 240 parts; at Florence to 280 parts; ted Bluff, 316 parts; at Pecos City, Tex., to 400 parts; and below 'ecos City to over 500 parts. Five hundred parts of soluble matter n 100,000 parts of water, when added to the soils of the Pecos Valley, nay be taken as the extreme limit of endurance for plants, while 50 or 300 parts mark the danger point at which the results of the use f the water are very uncertain.

It should be stated that only about 50 per cent of the solid matter ontained in the Pecos waters is harmful, and the above figures should e divided by two to obtain the real concentration so far as really harm- ul salts are concerned. The inert soluble matter consists of gypsum nd carbonate of lime held in solution through the influence of other nore soluble salts. These substances crystallize out on the evapora- ion of the water and are not readily dissolved thereafter. These are, herefore, not liable to accumulate in the soil in a soluble form, and for his reason due allowance should be made for the proportion they make f the total amount of soluble matter in the water.

The limit of endurance for most cultivated plants in a water solution s about 1 per cent or 1,000 parts of the readily soluble salts in 100,000 parts of water, but it must be remembered that in field culture the vater is applied to soils already containing more or less of these salts, nd also that evaporation and consequent concentration immediately et in after the application of water. It was found at Carlsbad that bout 300 parts of soluble matter per 100,000 parts of water marked the xtreme limit of safety of the use of water at that place.

In the use of water for irrigation purposes so close to the limit of plant endurance, as occasionally occurs at Carlsbad, there are certain precautions which can and should be taken to insure the safety of the crops and the permanence of the fertility of the soil.

In the arid climate of New Mexico where evaporation is so excessive the actual amount of evaporation becomes an important factor in deter- mining the condition of the water. It is stated that the evaporation at Carlsbad amounts to about 10 feet in depth in the course of a year. Evidently, therefore, the deeper the reservoir in proportion to its area the more economical it is as regards the condition of the water. The same bulk of water in a reservoir 20 feet deep with perpendicular sides would lose just half as much by evaporation as if the reservoir were 10 feet deep and the surface area twice as great. There are, of course, engineering conditions which have to be considered in the construction of such reservoirs.

As the absolute evaporation from an equal area of water surface is just about the same where the reservoir is full or nearly empty, the

water in a partially filled reservoir becomes more concentrated as a result of this evaporation than where the reservoir is full. So far as the condition of the water is concerned, therefore, it is advisable to keep the storage reservoir well filled. In cleaning or repairing the reservoir the water is occasionally drawn off in the fall or winter at the beginning of the dry season when work is slack and the danger of floods is at a minimum. If, however, the water has to stand for a long time in this low stage the evaporation has much more effect upon the concentration than if the surface had not been lowered. If the usual rains are delayed and this water has to be used to start the crop, it may be so concentrated as to be unfit or unsafe for use. This is a matter which requires the careful consideration of the engineer in charge.

In a large drainage area, such as is found in the upper part of the Pecos Valley, the alkali salts usually come to the surface and form a crust over extensive areas during the dry season. With the first floods much of this salt is carried down into the river and, as a consequence, the first waters of the spring floods at Carlsbad contain a dangerously high salt content. If the reservoirs have been low and the waters are already concentrated the first flood waters may make the waters of the reservoirs unfit for use until further rains and floods have come down. Where possible, under conditions of this kind, it would be advisable to divert the first flood waters and not allow them to enter the reservoirs at all. In many places, of course, this would be an engineering feat of so much difficulty and expense that it could not be considered, but where it is possible, under conditions such as prevail at Carlsbad, it would be very desirable.

With the irrigation water so near the limit of endurance as sometimes prevails in the Pecos Valley it would be desirable to have a record kept and daily or weekly notifications sent to the users of the water of the actual conditions as regards the salt content. With one of the electrical instruments in use by the Division of Soils, the total salt content of the water could be determined in a few moments, at the reservoir, in a flume, in the canal, or in the river before it enters the reservoir. The total salt content thus determined, representing the condition of the water, should be communicated by telephone or otherwise to the principal landowners and users for their information and guidance.

It may be perfectly safe to use water of a relatively high salt content on certain well-drained soils when it would be ruinous to allow the same water to be used on a poorly-drained soil containing a high salt content. Furthermore, the previous condition of the soil and the kind and age of the plant has much to do with the safety in applying water which approaches the limit of crop endurance.

The soil map accompanying the report of Messrs. Means and Gardner shows that there is no excess of alkali in the Pecos sandy loam,

hich includes most of the cultivated land in the valley, except in a w draws and low places. With this map and the alkali map it ould be possible to determine the limit of the salt content of the ater which it would be safe to use on any locality given on the map, s well as for the different plants at their different stages of develop- ent. This is a matter which should receive the thoughtful attention nd consideration of all who are interested in the development of griculture in such a community as this.

At several points along the Southern Canal, in the Carlsbad dis- rict, the canal bank is thrown up on the lower side and the water is llowed to rise and flow over an area of from a quarter of an acre to sev- ral acres in extent on the upper side, forming a small lake. This is vowedly done to save the labor of making embankments and for ncreased storage purposes. It is an exceedingly pernicious thing to llow, however, for two reasons; namely, it presents a relatively large urface for evaporation and in this way increases the concentration of he solution to a marked extent, and the seepage from the canal is very reatly increased by allowing the water to spread out over such an rea. It is very common to find small ponds or lakes some distance rom the canal, formed and supplied by the seepage waters from the anal. The ordinary seepage from the Southern Canal probably ac- ounts for a large amount of the trouble from seepage waters in the Carlsbad district. This trouble is confined largely to the conglomerate nd gypsum areas, but it is unquestionably felt to quite a marked xtent in other soils. It was found that in one place in the gypsum area he canal lost about 20 per cent of its volume in a distance of about ¼ miles. This is going on all the time the canal is flowing. There is o question but what the excessive subirrigation of the gypsum lands, nd probably of the other subirrigated lands shown upon the under- round water map, is due to the seepage from the canal and its later- ls, rather than from overirrigation by the farmers. This matter of he storage ponds along the canal, which has just been referred to, is esponsible for a great deal of this unnecessary injury.

In Bulletin No. 14 of this Division, on the Alkali Soils of the Yellow- tone Valley, attention was called to the fact that lands receiving the ost careful treatment by the people living on them might be ruined y seepage waters and alkali caused by the seepage from canals or by e improper use of water on a neighboring place, perhaps several iles distant. Many instances of this kind have been seen, not only the Yellowstone Valley, but in the Pecos Valley, which is now der consideration. It seems to me that this is a matter for the tates or for Congress to take up with a view that provision be made statute that reasonable care be taken to protect ditches and canals m undue loss of seepage waters and to provide that reasonable care exercised in the use of irrigation waters. Provision should be made r the recovery of damages through civil suits in case of injury to

property through such sources. It is quite as important for the States to exercise such police power in protecting a man's property from destruction by seepage waters from a canal or from injury by the excessive use of irrigation water by a neighbor, as to protect his property from depredations of any other kind.

It is of the utmost importance, in a locality similar to the Carlsbad district, where the seepage from the canal is seen to be doing so much injury, that the canal company be required to provide against this loss of water through seepage, and so protect the surrounding country from the dangerous effects of the seepage waters which are seen to occur. Particularly is this necessary where the canal goes through a loose gravelly area or through the gypsum soils, which have the peculiar property of transmitting seepage waters so readily and for such long distances. There are various ways in which such protection can be afforded, ways that are voluntarily used by the water companies in districts where water is scarce. It is neither right nor reasonable to permit the wide destruction of property values simply because water is plentiful and is in itself cheap. Where the cause of the trouble is shown so clearly as in the Carlsbad district there should be no hesitation in providing adequate protection to the community.

The maps show that with few exceptions the soils of the Carlsbad district are free from excessive quantities of alkali. With the knowledge gained through this investigation of the dangers inherent in the relatively large salt content of the waters, to the danger from seepage from the canals and from overirrigation, and the nature of the soil, it should be possible to provide that such careful methods be used that certain lines of agriculture can be successfully carried on under the prevailing conditions.

There are other questions which determine to a considerable extent the economic value of crops in this area. For example, the soils of the valley contain a large amount (from 10 to 20 per cent) of carbonate of lime. It is the experience in certain localities that apple trees will not grow well with a subsoil containing so much as 20 per cent of lime. In the matter of sugar beets also, where the water used contains an undue amount of salt, a large proportion of the sugar fails to crystallize, and is lost.

There are other questions quite as important as these to be considered, but they belong more particularly to some of the other divisions of the Department of Agriculture.

One thing should be said in connection with the Carlsbad area, which seems rather anomalous in view of the statements of other investigators, namely, that with a water supply so near the limit of crop endurance as this becomes at times and in those areas in which there is already a large accumulation of salts, that economy in the use of irrigation water, which is generally recommended in alkali regions, is one of the worst methods which can be practiced. Where the soil contains a relatively large amount of salt and but little water con-

taining much salt is frequently applied, the ordinary evaporation will increase the salt content of the soil to such an extent that crops can no longer survive; whereas if adequate drainage is provided, and a large amount of water is used, the excess of salt resulting from the evaporation of previous applications of water, may be removed, and the soil moisture be maintained at nearly the same concentration as the water supply. It is advisable, therefore, over certain localities, at least in the Carlsbad district, to provide underdrainage where necessary, and then use relatively large applications of water, rather than frequent small applications. If the drainage is adequate, it may be that an occasional flooding in the winter would leave the land in good condition for the coming season, and that during the season frequent small applications can then be used to advantage.

A portion of the town of Carlsbad lies directly under one of the conglomerate banks. The seepage through this from the canal has raised the water surface to within 2 or 3 feet of the surface of the ground. As a consequence of this the shade trees have suffered, and many of them have died. An attempt was made to improve the conditions by stopping the irrigation altogether. This made matters worse. The water in the soil concentrated so rapidly and to such an extent that the trees began dying off quite rapidly until, on the advice of Professor Skeats, irrigation was once more resumed, and the conditions were ameliorated. The irrigation in this case should be supplemented by underdrainage, which would not only lower the water level in the soil and secure better aeration, but it would secure better control of the salt content of the soil by occasional flooding.

Some observations by Mr. Gardner on these soils are interesting and instructive. A series of tubes was inserted into the soil down to the water level, so that the fluctuations of the water level could be observed with a rod or float. In addition to this, a series of electrodes was put into the soil at intervals 2 or 3 inches apart down to standing water. It was possible by these means to watch the effect of irrigation on the soil moisture. Before irrigation the level of standing water was 3 feet. Within thirty minutes after the irrigation water had reached the place both the tubes and electrodes showed the level of standing water to have risen to the surface of the ground. The water was held on for some time after the complete saturation had been effected, and after it was stopped it took several days for the natural drainage to restore the normal conditions and for the water level to sink to its former level. Such conditions must be unhealthy for crops, and if the excessive flooding and complete saturation is necessary to remove accumulated salts, artificial drainage should be introduced to quickly remove the excess of water used, as well as to lower the level of standing water in the soil.

The maps show that in the Roswell district extensive areas of land are already ruined by seepage waters and by alkali. This has unquestionably come from the seepage from the canals and from overirrigation. The area is small and seems adapted to intensive farming, and

there is no reason why at comparatively small expense these lands should not be underdrained and the present trouble entirely removed. The water supply is so good that with adequate drainage provided, there is no question about the ease with which the damaged land could be reclaimed.

The conditions are so clearly presented in the report and accompanying maps and the remedies are so obvious that further comment in this place is unnecessary. The investigations certainly point to a most encouraging prospect for success in the Roswell district.

Pecos City and Barstow are approximately 80 miles south of Carlsbad. The Pecos River, supplying these places with irrigation water, gathers the unused, waste, and seepage waters from the Roswell, Hagerman, and Carlsbad irrigated areas, and the salt content of the water is so great as to be beyond the limit of endurance for most plants during the greater part of the time.

Nothing can be said, no advice can be given for the successful irrigation of lands where the water supply has so large a salt content as at these places. It is just possible that at certain times of the year and in certain states of the water the water supply may be pure enough for successful irrigation, and that by the construction of large storage reservoirs and the diversion of the water when the salt content reaches a certain maximum a small irrigated district could be maintained; but these are questions which would require a detailed investigation extending over a number of years. It would be advisable to have records made of the conditions of the water from day to day for at least two or three years, and not rely upon the single determinations which have been made, although these are supported by the experience of the past years in the practical irrigation of the lands.

Mention has already been made of the occurrence of the root-rot disease in the Carlsbad district. So far as can be determined with a single season's observations and without the necessary investigations of the vegetable pathologist, it would seem that the character of the soil with the high content of carbonate of lime, which is known to be prejudicial to certain crops—especially apple trees—and with the water supply so charged with salts as to be near the limit of endurance for crops, the vitality of the crops would be so low that they would become peculiarly subject to diseases which in a more vigorous condition they could readily resist. This is a matter, however, for the Division of Vegetable Physiology and Pathology, and I consider that these records and maps would form a very valuable basis from which they could work out economic problems in vegetable physiology and pathology which others have tried for years to study in the confined limits and under the artificial conditions of pot culture. It is a line of investigation which is well worthy of being followed out, as it is of the utmost economic importance not only in this, but in other irrigated districts of the West.

SALT LAKE VALLEY.

The Salt Lake Valley is the oldest of the modern irrigation districts and has been noted for the high state of cultivation of the lands by the Mormons. During recent years, however, complaints have been made of the damage by alkali and seepage waters of the lower levels, which were formerly the most productive soils of the valley. The tendency has been for the settlers to move farther and farther back into the higher benches.

The work of the field party was confined to that portion of the valley west of the Jordan River and extending to the Great Salt Lake and to the Oquirrha Mountains. This area comprises approximately 250 square miles, or about 160,000 acres. Of this large area only 40 square miles, or approximately 25,000 acres, are at present under irrigation, and 50 square miles, or 32,000 acres, are all that have ever been under successful irrigation. About 90 square miles, or approximately 58,000 acres, are above the canals and are at present not available for irrigation. There are about 125 square miles, or approximately 80,000 acres, in a vast level stretch of country west and north of Salt Lake City, extending to the Great Salt Lake. Of this it has been estimated that about 90 square miles, or approximately 58,000 acres, are capable of improvement through underdrainage or irrigation. The remaining 35 square miles of this area are in flats of heavy clay soil of low elevation, filled with alkali, which it would be inadvisable or impossible to underdrain.

The water supply of the Jordan River is reasonably pure and is well suited for irrigation purposes. The most recent canals were taken out near the Jordan Narrows and have nearly the same composition as the Utah Lake. Farther down the river gathers some alkali from seepage waters, but it also gains a considerable quantity of fresh water from mountain streams, so that there is considerable variation in the salt content in different parts of its course. There seems to be an ample water supply to irrigate all the land which could be brought under the ditch, but on account of the high salt content of the soil irrigation has never been successfully practiced on the 125 square miles of nearly level land west and north of Salt Lake City.

Of the 50 square miles which have been under the ditch and successfully cultivated, about 10 square miles, or one-fifth of the whole area, have been ruined by seepage and alkali salts from the higher levels. This abandoned land is now wet and swampy, and about 1,000 acres are actually covered by large lakes which have been formed by the seepage from canals and irrigated lands. These abandoned lands were originally the most fertile portion of the area, and being for the most part nearer the city had a value probably of not far from $80 to $100 per acre. This damage is gradually extending back toward the bench lands. It could readily be stopped with more care in the construction of the canals and in the use of water supplemented by thorough drainage.

There is a scheme on foot at the present time to construct a high-level canal, taken out from the Jordan Narrows, to be supplied by hydraulic pumps, which would bring under the ditch a large portion of the 90 square miles at present above the irrigating canal. This would increase the danger, however, to the lands at present under irrigation, and steps should be taken to protect these lands and prevent the encroachment of the seepage waters and alkali on the lower levels. This is a matter which could easily be accomplished at a moderate cost. It would necessitate more careful work in the construction of the canals, to prevent seepage, and adequate drainage on the lower levels.

The greatest problem, however, in the valley at the present time is the reclamation of about 100 square miles of the land lying adjacent to and west of Salt Lake City. There seems to be no question about the feasibility of the engineering problem in underdrainage there, or about the efficiency of underdrainage in the reclamation of these lands with the water supply so good and so abundant as it is. The cost of underdrainage would be no greater than for similar lands in the States of New York, Ohio, or Illinois; while the value of these lands, being so near Salt Lake City, would certainly be as great as in those States where underdrainage has been so extensively carried on and is considered so essential in the cultivation of the land and the maintenance of its fertility. There would thus seem to be a fine opening as a commercial enterprise in the development of these lands through underdrainage.

There is a mean average fall from the ridge running in a northwesterly direction from Salt Lake City of about 2 feet to the mile down to the lake. This would be ample for the main drainage canals, as the irrigation canals are frequently built with about half this fall per mile. The drainage of these lands would be rendered comparatively easy through the numerous draws already existing, which are from 6 to 8 feet below the general level of the surface into which the drains could empty. Good tile clay is abundant in the vicinity and tile could be made and delivered to the farmer at a reasonable cost.

Over such an extensive area as this the drainage systems should be well devised and should be a community affair rather than constructed through individual efforts. The cost of underdraining these lands with tile is estimated at from $10 to $20 per acre, depending upon the texture of the soil and the distance apart of the drains. These lands at present have no value or only a mere nominal value for grazing purposes. The irrigated lands of the locality are worth from $60 to $80 per acre. If these lands adjacent to Salt Lake City were reclaimed through underdrainage they would be worth certainly from $60 to $80 per acre, and much more than this if held as suburban property. This reclamation work should be carried on as a community enterprise, aided perhaps by county or State credit, as has been done in many sections of the country where similar enterprises are undertaken.

These are the great problems presented in the Salt Lake Valley, problems presented very clearly in the report prepared by Messrs. Gardner and Stewart. From the evidence there presented, and especially from the maps, the actual conditions in the valley may be clearly understood. The soil map shows the distribution of the different types of soil, the Jordan sandy loam forming by far the greatest extent of valuable land. This soil is not originally very alkaline and it is easily drained and improved. The Jordan loam is rather more difficult to deal with, while the Jordan clays, from their slight elevation and the impervious nature of their material and the large accumulation of salts in them, would present great difficulties and would perhaps prove impossible of reclamation.

Where this Jordan clay occurs at a reasonable distance from the surface, however, it undoubtedly adds strength to the lands. Where it comes too near the surface it is an element of danger, as it impedes the drainage of the soil. The relation of these soils to drainage, seepage waters, and alkali should be very carefully studied by the farmer.

The alkali maps and the underground water map show very clearly the conditions prevailing over the whole district. Attention should be particularly directed to the very large accumulation of alkali in some of the areas north of the Twelfth street road. Also the remarkable accumulation of sodium carbonate or black alkali should be considered. This sodium carbonate occurs in places to as great an extent as 3 per cent in the surface foot of soil, while the composition of the crust which forms over the surface indicates at least a possibility that it may be sufficiently pure for commercial purposes.

One interesting thing in connection with this area is that calcium chlorid has been found to occur in very large proportions in some of these crusts, and strontium is also present in appreciable amounts. No attempt was made to investigate the economic importance of these salts, but the indications are that it would be worth while to look into the matter further from an economic point of view.

The investigation of the hardpan forming on the shores of Great Salt Lake is interesting and valuable. It seems to me that the whole matter of the occurrence and formation of hardpan in soils is very nearly solved, and that before very long this troublesome question in agricultural practice will be fully understood. The observations of Messrs. Gardner and Stewart and the paper by Dr. Cameron have contributed important facts and suggestions toward the solution of this problem.

THE CONNECTICUT VALLEY.

The report of Mr. Dorsey on the soil survey of the Connecticut Valley, with the accompanying map, presents so clearly the conditions prevailing there that little comment is necessary at this place. Furthermore, it is but the basis of a very extensive and comprehensive

investigation by this division, authorized by Congress in the present appropriation bill.

The map shows the distribution of the soils of the valley, which are described with all necessary detail in the accompanying report. The sides of the valley are formed for the most part from the glacial deposits of Triassic sandstone, and in the northern part of diabase. The soils of the valley proper are sediments which have been washed over and assorted in the great lake which is supposed to have covered this area in prehistoric times. Some of the soils occur in well-defined terraces, which formed the shores of the old lake, or which were formed subsequently by the river and streams. Over much of the area, however, these terraces are ill-defined or entirely lacking, and, from the differences in elevation of the same soil formation in different parts of the valley, there are even evidences to disprove the terrace theory of the physiography of the country. Certain it is, however, that the soils were laid down by water, and that in so doing they were sorted out in various grades of fineness. Beginning with the present meadows, which are composed of very fine sand and silt, the Podunk region is in a well-defined terrace elevated about 20 feet above the meadows and is composed of one grade coarser material, but still so fine as to be just distinguishable by the eye.

The Hartford loam, forming the principal tobacco soil, in extent at any rate, is a grade coarser than this, while the Windsor loam, believed to be the original bottom of the old lake in its shallowest portion, is very coarse sand, containing some gravel. These Windsor sands produce the finest wrapper leaf when the season is favorable, but a good crop is secured only one or two years out of five.

As Mr. Dorsey points out in his report, the one great trouble with the Connecticut tobacco is that it does not conform to the present requirements of the cigar trade. The leaves are too large, the veins are too large, the base of the leaf is too glossy and lacks texture and style, while the color of the leaf is far from uniform. An attempt is soon to be made to secure a radical change in the type of the leaf by close planting, allowing many more leaves to the stalk, by very rapid growth, by shading, and possibly by irrigation. These experiments with the Connecticut tobacco will be undertaken in the hope of producing a leaf approaching more nearly the Sumatra type of wrappers, this type being generally accepted in this country as the standard for cigar wrappers.

With the intensive cultivation that this will require, it is quite possible that these Windsor sands may be looked to for the finest wrapper leaf. I am of the opinion that even with the present style of leaf it would pay to irrigate these lands where this could be done easily and cheaply, in order to secure a crop four times out of five at least where now it is only possible to obtain one or two crops out of five.

The Hartford loam is decidedly a safer soil and can be relied upon to produce a fairly good crop of the Havana seed leaf variety each year.

This tobacco has a peculiar "seedy" taste which it is desired to get rid of and it is possible that this may be accomplished through selection and breeding, if not by radical departures from the present methods of cultivation and fermentation.

Such questions as these will form the basis of an extensive line of investigations already outlined, requiring several years of systematic work.

CECIL COUNTY, MD.

The soil work for the Cecil County sheet has been completed during the present season, but the topographic base map has not yet been engraved and will not be available for publication before the fall of 1900. Photographs of the pencil copies were kindly furnished by the United States Geological Survey for the actual field work and transfers will be obtained as soon as the plates are engraved. The soil map will be published in cooperation with the Maryland geological survey.

LABORATORY WORK.

The paper by Dr. F. K. Cameron, soil chemist of the division, cooperating with the Division of Chemistry, together with the one by Mr. Lyman J. Briggs, physicist of this division, shows some important advancements made in the methods of soil investigations, which have very materially increased the efficiency of our field parties and have made them quite independent now of the laboratories, except so far as the laboratories will be used to investigate and explain the basis upon which the soils have been classified in the field in order to show as fully as possible the physical and chemical peculiarities of the different soils.

The electrical methods of determining the moisture and salt content of soils are based upon the conception of the soil moisture as being a solution of a mixture of more or less difficultly soluble substances. Dr. Cameron has carried this further in the application of the modern theories of solution to the study of some of the most difficult soil problems. As a result of this, new methods of field analysis of mineral substances have been devised, and the occurrence of certain mineral substances in the alkali soils and crusts has been explained with suggestions for the more rational treatment of the land, and, lastly, the occurrence and mode of formation of hardpan has been explained more clearly and more rationally than ever before. The work naturally leads up now to a study of the interesting and important subject of absorption by soils and the chemical and physical changes induced by fertilizers.

FIELD METHODS FOR A SOIL SURVEY.

After years of careful work the methods adapted to the field survey of soils have been perfected, so that now the field parties are quite independent of the laboratories, at least in the preparation of their

maps. A brief description of the field methods in use by the division at this time may be of value to those who are interested in the work.

In the field classification of soils all features are taken into consideration which appear in any way to influence the relation of soils to crops. The classification is based mainly upon the physical properties and condition of the soil as determined by the soil expert, but it is not based solely on this. Any chemical feature, such as deposits of marl, of highly calcareous soils, or of highly colored soils, is considered, as well as the character of the native vegetation and the condition of the crops. The topography of the country is often a very safe guide in outlining the boundaries of soil conditions. For this reason it is very advisable that there should be reliable maps of the different districts to base the soil work on and that these maps should show the important topographic features.

In order to make the maps of the greatest possible local value it has been decided to publish the soil maps, so far as possible, on a scale of 1 inch to the mile. Local variations in the character of the soil of less than one-fourth of a mile in extent are generally ignored, unless this variation constitutes a very prominent feature, such as a strip of meadow land along a stream, or unless there are a number of small areas by which a certain character is given to the district. For example, if rocky areas occur, small in each case, but extending over large areas, they should be indicated in some way upon the soil map.

The basis for the field classification of the soils of the Connecticut Valley may be seen from Mr. Dorsey's report. The meadow land is not only set off as a distinct physiographic feature, depending upon the topography of the country, but it is a very fine sediment of silt and very fine sand, which is easily recognized and is distinct from any of the other soils of the valley. The judgment of the soil expert in the field in a matter of this kind in deciding on the texture of these soils is very reliable.

The Podunk loam is a grade coarser than the meadows, and this also is very apparent to the observer in the field. The difference in texture in these soils can be recognized quite clearly in dried samples in the laboratory. The difference in the character of the vegetation and in the relation of crops as seen in the field is very marked.

Extending back from the river on either side and at higher elevations is the Hartford loam, which is still coarser in texture, while the Windsor sands are very coarse angular quartz grains with a little fine gravel. The Triassic stony loam has a peculiar Indian red color and contains fragments of stones grading up in size to boulders. The Enfield loam is apparently a deposit of the Hartford loam immediately upon the Triassic stony loam, with an average depth of about 18 inches. The Chicopee gravelly loam, covering a large area in the northern part of the district, has so much gravel as to form a very conspicuous feature. These features, upon which the classification of these Connecticut soils

based, are quite plain and distinct enough in the field to outline the il areas.

In the preliminary work in Florida, which was mentioned in Bulletin p. 13 of this division, it is evident that the classification of the soils ere had to be made mainly from the distribution of the native vegeta-n. The different classes of soils there varied but little in their ysical and chemical properties, but there is a very great difference the native vegetation and in the adaptation to crops. The reason r this is not at present understood, but it is mentioned here to show at the basis for the classification of soils differs under different cir-mstances.

The survey of the alkali soils of the far West is much more difficult, it involves other determinations and observations in the field. There hould always be a soil map, an alkali map, an underground water ap, and where sodium carbonate exists in appreciable quantities a eparate map should be made showing the distribution of this pernici-us substance. It is very important that the data for the soil map be irst collected and the soil districts outlined on the best available base ap. This will enable a much more intelligent study of the alkali roblem to be made than if the distribution of the soils had not pre-viously been determined. An example of this can be seen in the Salt Lake sheet which accompanies Mr. Gardner's report.

As a rule the clay soils on the flats and draws of the great alkali plain west of Salt Lake City contain the greater amount of alkali, the loam soils next, then the sandy loam, and finally the sandy soils. This is partly due to the texture of the soil and the influence of this texture on the drainage, and partly to the physiography of the country as determining the drainage question.

Having located these soils and considered the influence of the topography, a comprehensive study of the alkali conditions is much simpler.

In the preparation of the soil maps only such conditions as are apparent in the field, such as the texture as determined by the feel and appearance, the depth of soil and subsoil, the amount of gravel, the condition as to drainage, and the native vegetation or known relation to crops, are mapped.

Having determined upon the final classification of the soils of a locality, each well-defined area is established as a class and given a local name. No attempt will be made for the present to correlate a loam soil in the Connecticut Valley with a loam in the Susquehanna Valley in Pennsylvania unless the two are very clearly identical in origin, in character, in relation to crops, and under essentially the same climatic condition. If there is any apparent difference it is preferable to give each a local name and describe each separately in the most careful and exhaustive manner.

Having decided upon the classification, samples should be taken from each soil formation in order to study the texture and chemical

composition. For this purpose each area should be represented by at least eight or ten samples so selected that they will represent the average conditions of the area. The depth to which these samples should be taken depends somewhat upon the locality. In the eastern districts the samples are usually taken to a depth of 3 feet and occasionally deeper. In the western district, where the soils are more uniform and where the alkali conditions are important, the samples are usually taken to a depth of 6 feet and occasionally deeper. The samples representing any particular formation should be fully described and such a number of them taken for examination, both physical and chemical, as may be thought necessary to bring out the striking features of the soil. The information so acquired will be used, not as heretofore to base the classification upon, but only to describe the samples mentioned in the text and to show the relation of the different soils of the area.

In the construction of the alkali maps it was formerly the practice of this division to take borings at more or less regular intervals along section lines and afterwards construct a map from the field notes after they had been corrected and the figures reduced in the laboratory. Much time can be saved, however, and greater accuracy secured by preparing the maps in the field as the work progresses, as is always done in the case of the soil maps.

Having outlined the soil areas, each area should be studied in sufficient detail to determine its condition as regards alkali. Very frequently, from the character of the soil and the topography of the land, the conditions of alkali over extensive areas can be very satisfactorily determined with a very few salt determinations. The alkali conditions of each soil should therefore be studied in this way.

It is usual to make borings for alkali work to a depth of 6 feet or more. It has been found, however, that the data so collected is really more than is necessary for the construction of an alkali map. It is now considered sufficient to examine the first, third, and fifth foot of the boring for alkali salts and neglect the second and fourth foot.

In plotting the results on the map it has been customary to locate the borings on the base map and faintly indicate the salt content of the first, third, and fifth foot. Having determined the limits which it is desired to show upon the map, lines are drawn around the figures in such a way as to separate the areas falling within or without the limiting values. It has been found better to use judgment in the placing of these lines, based upon the salt content of these three depths, rather than to accurately outline the conditions of the surface foot or of any given depth below the surface. Very frequently from some local cause, such as a slight elevation or a ridge formed in the cultivation of the soil, etc., the surface foot may contain a small amount of alkali, while the lower depths will show an excessive amount. These lower depths thus serve to check any error that may occur from a consideration of the surface conditions. Furthermore, even if the surface foot is shown

be free from alkali over a considerable area which has never been rigated and excessive quantities are shown in the other depths, it uld be entirely misleading to show the soil free from alkali as a surce map would, as trouble would very soon be apparent after irrigan was started. It is not considered advisable to publish maps showg the alkali conditions at different depths, but far better in arranging e map to rely upon the judgment of the soil expert in outlining what ay be considered as safe, dangerous, or worthless soils, so far as alkali lts are concerned.

This work has formerly been done in the office after the salt content rresponding with the actual resistances in the field had been reduced. he present practice, however, is to map these salt areas in the field in e same manner as the soils are mapped. A salt map is usually shown colors, these colors indicating the soils having a very small and fe alkali content, those in which the alkali is too strong for crops, and ntermediate grades, which may be considered dangerous and which ould have to be handled with care and judgment. In the work so far his medium grade has a limiting value of one-half of the maximum—hat is, if the maximum amount for a crop of any particular kind of lkali is 0.50 per cent, the lower limit of the danger line would be placed t 0.25. This is an arbitrary figure, but one which seems to be justified y the facts.

In testing the limiting value it is customary to look for a crop such s alfalfa or wheat, which is showing the effect of alkali in some portion f the field. Very frequently the middle of the field may begin to die ut while the edges are still flourishing, or perhaps one corner will show he effects of alkali before the rest of the field is affected. By careful work on such a field as this the limiting value can be determined. The lectrical resistance of the soil at various points in such a vicinity hould be determined, corrected for temperature, and the limiting value be selected from the resistance figures so obtained.

As a result of the work this season, the following directions have been issued for the guidance of the field parties:

DIRECTIONS FOR MAPPING ALKALI SOILS IN THE FIELD.

The contour intervals for the alkali maps are to represent, respectively, 0.20, 0.40, 0.60, 1, and 3 per cent of salt in the dry soil. The maps are to be constructed in the field directly from the resistances. The work is to be standardized in each district in the following way:

Take eight or ten crusts, including the top inch of soil; or, if crusts can not be obtained, take the strongest alkali soils from different places over the whole area. Fill a large cup or tumbler about one-third full with a crust or soil, using more or less according to the richness of the material, and nearly fill the tumbler with distilled water. Stir vigorously and allow it to subside for a short time. Treat the eight or ten crusts or soils in the same way. Determine the electrical resistance of the solutions in the cell. Take an amount of the strongest solution equivalent to at least 200 cc. having a resistance of 5 ohms, and add to it a volume of each of the others proportional to the resistances determined. This mixture, containing approximately equal quantities of salt from the eight or ten localities selected, is

evaporated to dryness on a common range in a graniteware saucepan. Before the salts begin to crystallize out and when the clay and organic matter are well flocculated, filter and evaporate the clear filtrate, stirring at the last to prevent caking. Gently heat the residue to drive off the water of crystallization of the sodium sulphate and sodium carbonate. If the original solution can not be filtered clear at any time before the salts begin to crystallize out, a second evaporation may be necessary.

A 10 per cent solution should be made of this salt in distilled water. The electrical resistance of this 10 per cent solution in any cell, divided by 0.24, will equal the resistance of a saturated sand or sandy loam soil in the same cell when completely saturated and at a temperature of 60° F., when the soil contains 3 per cent of salt. This solution is then to be diluted and the resistance determined at various concentrations, corresponding to the limiting values of the soil map for four grades of soil. The table for temperature reduction have been published in Bulletin No. 8 of the Division of Soils.

The dilutions are as follows, the figures representing cubic centimeters of the 10 per cent solution to be diluted and made up to 100 cubic centimeters:

To obtain limiting values.

Salt in soil.	Volume of 10 per cent solution in 100 cc.			
	s. and ssc.	sc.	scc.	c. and hc.
Per cent.	*cc.*	*cc.*	*cc.*	*cc.*
3.00	100.0	79.5	71.4	66.6
1.00	33.3	26.5	23.8	22.2
.60	20.0	15.9	14.3	13.3
.40	12.0	10.6	9.5	8.9
.20	6.0	5.3	4.8	4.4
Resistances to be reduced to 60° F. and divided by	.24	.275	.29	.30

The result will give the cell resistance at 60° F. corresponding to the limiting values, to be inserted in a suitable table.

To correct for any lime sulphate which does not redissolve, take the resistance of the solution before evaporating. Then evaporate in a separate dish a measured portion, such as 100 cc., heat the residue to char the organic matter, dissolve, make up to the same volume as before, and take the resistance. Any difference in resistance will be considered due to salts having gone out of solution, and all resistances used in the limiting values are to be decreased by the proportional increase in resistance so found before being entered in the table. Or the weight of salt for the 10 per cent solution may be increased in proportion to the differences in resistance.

DIRECTIONS FOR ESTIMATING SODIUM CARBONATE AND CHLORIDS IN SOILS.

Take a known volume (or weight) of saturated soil, wash into a 250 cc. flask, and fill to the mark with distilled water. Take 50 cc. of the solution (a slight turbidity will not matter) and titrate with N/10 acid potassium sulphate, using phenolphthalein as an indicator. Then add a few drops of potassium chromate as an indicator to the same solution and titrate with N/10 silver nitrate.

One cc. N/10 Na_2CO_3 = .005266 grams Na_2CO_3.
One cc. N/10 NaCl = .005806 grams NaCl.

Construct the sodium carbonate map in the field from the volume of solution used. Limiting values will be 0.3, 0.2, 0.1, and 0.05 per cent of dry soil. The limiting values

or each dish are found in the following way: Multiply the volume of saturated soil, epresented by the solution taken for titration, by the numbers in the following able:

Na_2CO_3 in soil.	s. and sac.	sc.	scc.	c. and hc.
Per cent.				
.30	.832	.752	.720	.689
.20	.454	.502	.480	.459
.10	.277	.251	.240	.230
.05	.138	.125	.120	.115

The results so obtained are the cubic centimeters of N/10 solution of sodium carbonate corresponding to the limiting values, to be inserted in a suitable table.

If it is desired to reduce the volume of N/10 $AgNO_3$ to per cent of NaCl in dry oil, the following formula may be used:

$$\frac{V \times .005806}{V' K}$$

V = cc. N/10 $AgNO_3$ solution used; V' = volume saturated soil represented in amount of solution titrated; K = constant for type of soil, as follows:

s. and sac. (sand and sandy loam) = 1.46; sc. (loam) = 1.32; scc. (clay loam) = 1.26; c. and hc. (clay and heavy clay) = 1.21.

If the resistances are close to the limits, a temperature reduction should be made in the field and a decision reached there as to which class the soil should be assigned. This greatly simplifies the work, lessens the calculations, and insures greater accuracy, because with the soil areas in view and with the general topography of the country the boundaries of these limiting values can be more accurately drawn than if the work were subsequently done in the laboratory from the field notes.

In like manner, the sodium carbonate map can be constructed in the field from the amount of standard solution of acid potassium sulphate required to neutralize the alkali in a given volume of saturated soil.

In the work so far undertaken Hilgard's value of 0.1 of 1 per cent of sodium carbonate has been taken as the limiting value for crops. The minimum value for the danger line is taken arbitrarily as 0.05 of 1 per cent. The amount of acid potassium sulphate required to neutralize a soil containing 0.1 of 1 per cent of sodium carbonate can easily be determined for any given volume of saturated soil and the survey can then proceed upon this basis in the classification of the black alkali conditions. No calculations are therefore required, except the ordinary standardization of the solutions and the determining of the volume of the measuring dish and the amount of dry soil which it contains. When these are once accurately determined, the work can proceed quite rapidly.

The construction of the water map is, of course, the simplest of all. Data are secured of the depths of all surface wells and wherever water is encountered in boring for samples. From the data thus secured the areas are traced upon the base map.

A SOIL SURVEY IN THE PECOS VALLEY, NEW MEXICO.

By THOS. H. MEANS AND FRANK D. GARDNER.

INTRODUCTION.

The southeastern part of the Territory of New Mexico comprises three distinct topographic features. The mountains of central New Mexico, including the Guadalupes, White, and Sacramento mountains, with the Santa Fe Range, mark the western boundary of the great series of plains extending westward from the mountains of Arkansas. On the eastern boundary of the Territory of New Mexico the Great Staked Plains are the most important feature. These plains form an elevated plateau with a uniform slope to the east. The western escarpment of the plateau forms the eastern limit of the Pecos Valley. The Staked Plains once, without doubt, extended to the foot of the mountains, with their western boundary somewhere near the present foothills which bound the east slope of the mountains, but the gradual uplifting of the western edge of the plain, together with excessive erosion along the base of the mountain, formed what is now known as the Pecos Valley. The present topography of the land is the result of the erosion and sedimentation of the stream in this valley—the Pecos River. At some period in its history, a time perhaps corresponding with the glacial period of the North, the Pecos carried much more water than at present, and during this time dams formed along the river either of hard ledges of rock or, by the filling up of narrow gorges with drifting material, caused the water to back up into shallow basins extending over great areas of country. In these basins or inland lakes the waters descending from the mountains deposited large quantities of sediment. The most pronounced basin of this type has been recognized and named the Tayah Basin. This basin lies on the lower Pecos, with its northern extremity near the Texas-New Mexico line, and extends for an undetermined distance to the southward.

Between the Delaware and the Black rivers, in a stretch of broken country, a second dam probably existed, and this obstruction backed the water up to some distance beyond Carlsbad. The sediments entering this basin were largely from calcareous rocks of the Guadalupe Mountain, and the soil formed from these sediments, weathering under the arid conditions of New Mexico, carries large quantities of carbonate of lime.

Between Carlsbad and Seven Rivers the Pecos flows through rough untry along the foothills of the Guadalupe Mountains, and in this ction of the river another obstruction once existed. The lake formed this dam extended as far north as Roswell and an undetermined stance westward from the Pecos. In this basin were deposited the liments which form the soils of the Roswell and Hagerman farming strict.

There are many minor basins and features of the Pecos River which re not studied, since their bearing upon the subject in hand is only secondary interest.

The rocks out of which the valley was cut vary in age from the carniferous of the Guadalupes through the Permian Red beds of the per Pecos, above Roswell, to the Jura-Trias and cretaceous sedints of the Staked Plains.

The carboniferous rocks are composed almost entirely of magnesian nestone, with beds of shaly limestone and thin sandstone. Such cks form poor soils under the arid conditions existing, since they ntain large quantities of lime without much potash or phosphoric id.

The Red beds consist of red sands and shales, with heavy beds of assive gypsum. Gypsum crystals are common throughout the formaon, and indicate formation from inclosed basins of sea water.

The Pecos River drains nearly the whole of the southeastern third of he Territory of New Mexico. Rising on the east side of the Santa Fe ange, the stream flows as a typical mountain stream through the cks of the mountains; then entering the horizontal rocks of the mesa ountry the stream assumes a meandering course broken at intervals y gorges and canyons. The general character of the Pecos below Rosrell is a series of basins filled with lake sediments and separated by ough country and hard rocks, through which the Pecos River is at resent cutting.

The main tributaries of the Pecos all come from the western side, and hey, too, are mountain streams, rising in the White, Sacramento, and Guadalupe mountains. The upper branches of these streams flow hroughout the year, but as soon as the level mesa country is reached nost of the streams sink into their beds. During times of high water he streams flow throughout their entire courses. The water which sinks along the upper stream courses follows under ground the general course of the rivers and appears along the basins near the Pecos in the form of springs. During its course through the ground the water dissolves small quantities of soluble matter and most of the springs contain the common alkali salts.

Above Roswell the main Pecos has few tributaries of any size. From Eden south small quantities of water flow in its channel throughout the year, though as far south as Roswell the flow sometimes is hardly more than 50 cubic feet per second.

At Roswell there are several permanent sources of supply which flow an estimated quantity of about 200 cubic feet per second. The Berendos, a series of large springs, rise from the edge of the large gypsum plains which extend for a distance up the Pecos Valley. The water from these springs has its origin in the crevices and underground channels of these gypsum plains, which form part of the Red Beds, and no doubt comes from the upper Pecos, the streams entering from the west across this gypsum plain. All of the waters coming from gypsum areas contain more soluble matter than do waters from the limestone strata of the underground river basins. This can be accounted for upon the assumption that the gypsum had its origin in inclosed basins of sea water, which always contains calcium sulphate in solution, concentrating through evaporation. Owing to the small solubility of the gypsum, this is the first salt crystallized out, and even though the water does not concentrate so far as to precipitate a large proportion of the sodium chlorid and the other more soluble salts, yet it includes small quantities of these salts.

There are three sources or springs from these gypsum plains, all of which unite into one stream flowing approximately 50 cubic feet per second.

The North and South Spring rivers rise from the underflow of the Hondo Basin, and the same basin furnishes the artesian water of Roswell. The springs rise in ponds from a number of small sources, and these small sources no doubt come from different depths, as their difference in temperature and chemical composition correspond very nearly with the temperature and composition of a number of wells of different depths around Roswell. The water is found in the lower layers of the cone of Hondo alluvium, which was formed as the flood waters overflowed into the basin of the Pecos. The water, coming as it does from the Hondo River, enters the Pecos at Roswell. In the upper parts of the river irrigation water in sufficient quantity to irrigate a few small farms is found, but after passing the Capitan Mountains east of Lincoln the river rapidly loses its water, and before Roswell is reached the river bed is dry during part of the year.

The artesian water at Roswell corresponds in composition nearly with the water of the Spring rivers. The temperature of the spring and artesian water is high—from 68° to 72° F. The water in the artesian wells rises to about the height of the springs, and since the level of the springs is below the level of the plain around Roswell, the use of artesian water for the irrigation of these plains is not possible.

Below Roswell is a series of draws emptying into the Pecos River. These draws are generally dry, but in their lower part below the Northern Canal small springs of ever-flowing water are found. Most of this water can be accounted for as coming from the Northern Canal by seepage.

The Felix River enters the Pecos a few miles north of Hagerman and, though dry during part of the year, it has a few permanent springs

ar its mouth. The Peñasco and Cottonwood are also streams of this pe.

At Seven Rivers an artesian basin, similar to the Roswell artesian sin, is found. At this place there is a settlement which uses the aters of the springs and the Seven Rivers for irrigation.

At Seven Rivers the valley of the Pecos closes in and the country is ore broken until Carlsbad is reached. Here the Pecos runs close to he foothills of the Guadalupe Mountains. The principal streams raining the Guadalupe slopes from the east are Dark Canyon, Black iver, and Delaware River. Both of the two latter run water through- ut the year, though the flow becomes as low as 10 cubic feet per econd during part of the season.

The Pecos enters the basin of the ancient lake Toyah about the New Mexico-Texas line, and flows through this basin to a distance of perhaps 50 miles beyond Barstow and Pecos City. Below this point the river is of no interest agriculturally.

THE CLIMATE OF THE PECOS VALLEY.

The climate of the Pecos Valley is arid—that is to say, the rainfall is insufficient to furnish enough water for the growth of crops over the entire valley. The drainage and surface water, however, is sufficient to irrigate a certain percentage of the land. The amount of land which can be irrigated stands in a direct relation to the rainfall and run off, provided the water is stored. The average monthly and yearly rainfall for the four years—1895 to 1898, inclusive—is shown in the accompanying table as compiled from the Weather Bureau records:

Rainfall at stations in Pecos Valley.

Month.	Mountain stations.				Valley stations.		
	East Las Vegas.	Galina Springs.	Fort Stanton.	Lower Peñasco.	Puerta de Luna.	Roswell.	Carlsbad.
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
January	0.60	0.48	0.70	0.93	0.93	0.60	0.34
February	.77	.51	.80	.22	.08	.52	.29
March	.76	.48	1.10	.06	.40	.35	.22
April	.82	.61	.70	.72	.32	1.06	.31
May	2.95	2.54	1.00	.52	1.36	1.22	1.22
June	1.99	1.10	1.90	2.13	1.58	3.02	2.32
July	4.13	5.14	3.10	5.99	3.51	3.83	2.59
August	3.43	2.43	4.00	3.11	3.06	1.91	2.35
September	1.62	1.13	2.30	1.61	1.07	1.05	1.09
October	1.93	1.31	1.50	2.24	1.24	1.88	1.05
November	.37	.43	.80	.10	.45	.34	.21
December	.68	.79	1.10	.86	1.09	.52	.64
Year	20.05	16.95	19.00	18.49	15.12	16.30	12.64

The stations given represent both the mountain and valley country. East Las Vegas, Galina Springs, Fort Stanton, and Lower Peñasco, are all in the mountains or foothills, while Puerta de Luna, Roswell, and Carlsbad are in the valley proper. The record at Fort Stanton is an average of seventeen years, ended 1891. The other records are for four years only. The greater part of the rain falls during the summer

months, from May to October, inclusive, in the form of heavy showers, local and of short duration. Falling, as it does, in torrents upon a dry surface, large quantities of the water flow over the ground and great floods are common in the streams. The lost rivers entering the Pecos from the west all have large bowlders in their beds, indicating violent torrents at some time during the year. Streams like the Dark Canyon at Carlsbad and the Felix south of Roswell, which are dry during the greater part of the year, have been known to suddenly fill their channels to overflowing with turbulent water from the heavy rains over the foothills and mountains. Streams of this character are the most difficult to manage, and when their control is attempted the works must be of such a cheap nature as to allow replacement every few years, or so substantial and so well protected by waste ways that their destruction is impossible. The first dam constructed, 6 miles above Carlsbad, was considered well protected with waste gates, but a heavy flood from the upper Pecos filled the dam so rapidly that water overflowed its crest and cut its way through the dam in a few minutes. A disaster of similar nature in Lake Macmillan was only prevented by cutting the dike which runs west from the dam.

The temperature of southern New Mexico is uniformly high in the valley, with very low relative humidity. The evaporation from a water surface is great. It has been estimated at 10 feet annually, though no complete years' records have been kept. During the spring of 1899 the evaporation from Lake Macmillan was measured as high as 4¼ inches per week. This represents probably a maximum evaporation for that locality. The mild character of the winters, the moderate elevation of the valley, and the dryness of the atmosphere all tend to render the climate beneficial to persons suffering with pulmonary diseases.

HISTORY OF IRRIGATION IN THE PECOS VALLEY.

Twenty years ago farming in the Pecos Valley was confined to a few small farms under irrigation. Long subject to raids from hostile Indian tribes, agriculture was confined to stock raising. The first white men to enter the valley were cattlemen, who did all in their power to discourage general farming, and as late as 1889 irrigation was found only on a few small places where ditches had been taken out of the streams. At Roswell the permanent water of the Spring rivers and the ease with which it could be put on the land, encouraged the most extensive farming. Private ditches were run from the North and South Spring rivers, and the extension of these same ditches forms the irrigation system of Roswell today. In the lower valley irrigation was confined to two farms in the Pecos Valley.

In 1889, encouraged by the success of irrigation in Arizona and southern California, a large company was formed to develop the Pecos Valley, and the present systems of irrigation are in a great measure the result of the investments made by this company. The plans of the

mpany contemplated installing an enormous irrigation system, head-
g in the canyon above Carlsbad. The canal was mapped to extend
far south as the New Mexico-Texas line. In Texas a second system
as to irrigate large tracts of land around Pecos City and Barstow.
ese plans contemplated the simple diversion of the Pecos, for, accord-
g to the statement of competent engineers, as published in the com-
ny's pamphlets, the flow of the Pecos is 1,000 cubic feet per second
its lowest stage. The Pecos, as a matter of fact, flows as low as 100
bic feet, at low stage, a few miles above Carlsbad. The construction
the large storage reservoirs easily overcame this error on the part
the consulting engineer, but at the same time it introduced a diffi-
lty in the use of the water which is very nearly insurmountable—
at is, the concentration of the waters through evaporation.

Upon the establishment of the irrigation plant at Carlsbad settlers
ere brought in from Europe. Most of these people were ignorant
American agricultural practices, and particularly ignorant of
griculture under irrigation. The officers of the irrigation company
ttempted to follow blindly the practices of other irrigation districts.
ttempts were made to introduce plants, trees, and shrubs from south-
n Europe. Large amounts of money were spent upon theoretical
hemes, misleading statements were made about the wonderful pro-
ctiveness of the soil, and the credulous immigrant invested all his
ealth at the suggestion of the promoters. Misled, living in a land so
ifferent from their native country, many of the attempts of the settlers
esulted in failure. There can be no question but that many of these
arly failures were due to ignorance on the part of the farmer, and also
ere due to the attempt to grow on a large scale plants entirely
nsuited to the climate or soil. Extensive farming, that is to say
arming on a large scale, has also been the cause of many failures.
Irrigation farming to be successful must first be intensive, then exten-
ive. Ignorance of the true conditions existing in soil and water and
he attempt of the original promoters to conceal the true state of
ffairs from the settlers have also been the source of much failure. Since
he farmers have begun to realize that grapes, fruits, grains, and truck
rops were not the kind of crops which gave encouraging results at the
tart, a gradual change in the agricultural practices has taken place.
Alfalfa and cattle or sheep raising are at present the industries of the
valley, and with such change a much more healthy state of affairs has
sprung up. In the Carlsbad district, and to a lesser extent throughout
the valley, sugar beets form a money crop at the present time.

The Roswell area is the result of a gradual development by private
resources, and the growth has been slower and more substantial. The
company bought up the greater part of the land, with the water rights,
in order to obtain control of the surplus water from the Spring rivers
and the Berendos for use in the Northern Canal. The Northern Canal
was constructed as a part of the general scheme for the valley, but it

has never been used as far as originally mapped. Under the canals now owned by the irrigation companies a water right is sold with the land, but a yearly water rent of $1.25 per acre is charged. The rental supposes the use of 2½ acre-feet of water per acre. Under the private canals and the land recently sold by the Roswell Land and Water Company in the Roswell area, an interest in the ditch is deeded with the land, the irrigator yearly contributing his share toward the support of the ditch.

THE IRRIGATION SYSTEMS OF THE PECOS VALLEY.

Excluding the small private irrigation ditches, which are found along the head waters of all of the tributaries of the Pecos River, there are four great systems of irrigation in the valley.

The Roswell irrigation system derives its water from the North and South Spring rivers, and the North, Middle, and South Berendos. From each of these sources a number of small ditches are taken out which supply the farms of the district. These canals were originally constructed by private enterprise, but were later bought up by the irrigation companies and their surplus water turned into the Northern Canal for use at Hagerman.

The Northern Canal system receives the unused, waste, and drainage water from the Roswell district, together with water from the Hondo when that stream is flowing. The Northern Canal flows from 90 to 125 cubic feet of water per second. The canal starts at a dam in the Hondo directly east from Roswell. This diverting dam collects the various waters of the Berendos, North Spring River, and the Hondo River, and where the canal crosses South Spring River a second dam is constructed, which diverts the water of the South Spring River. For a distance of nearly 20 miles below South Spring River no water is taken out from the canal. On both sides of the Felix, level farming land is watered from the Northern Canal. The canal extends to a distance of about 5 miles beyond the Felix River.

The Southern Canal system derives its water from the Pecos River by storage. Two large reservoirs have been constructed—one at Seven Rivers, being 8 miles long and an average of 1¾ miles wide, while the second, a much smaller reservoir, is situated 6 miles above Carlsbad. From the lower reservoir the water is turned into a canal 70 feet wide at the top. Four miles below the dam the canal divides, the main branch crossing the Pecos by a terreplein and flume and the smaller branch following around the east side of the river. The eastern branch at present stops at a point opposite Carlsbad, though the canal was planned to run about 18 miles below Carlsbad and discharge into an alkali lake (Lake Surprise). The western branch or Southern Canal proper carries from 200 to 225 cubic feet of water per second. The canal is 35 feet wide at the top and has a fall of 1½ feet in 5,000. Over a great part of its course only the lower side is banked, and the water extends back

into draws forming smaller lakes with a considerable storage capacity, though the loss by seepage and evaporation from these lakes is considerable and overbalances the advantage of storage. The water is taken out from the main canal through a system of head gates situated at convenient points. These main laterals are in turn divided into laterals and sublaterals. The entire control of the gates is in charge of the "ditch riders," who open and close the gates as the water is desired. The water right is sold with the land, though a yearly rental of $1.25 per acre is charged. This is the basis of 2½ acre-feet of water. A record is kept of the amount of water used by each irrigator and a proportional charge is made for all water used in excess of this quantity.

Some trouble has been anticipated from the filling of reservoirs by silt. No records are at hand to determine the amount which has been deposited during the time the reservoirs have been used; but large quantities of mud have been and at every flood are being deposited. The water of the Pecos at flood carries from 5 to 10 per cent by volume of silt, the greater part of which is deposited while standing in the reservoirs. This engineering feature of the problem of water storage requires very careful consideration before more large storage reservoirs are built on these mud-ladened flood streams.

At the town of Carlsbad a substantial masonry dam has been constructed, which furnishes sufficient power for the electric lights of the town, and also pumps water to a masonry reservoir upon the hill east of town.

About 13 miles below Carlsbad the Hagerman Canal takes water from a small diverting dam across the Pecos. This small canal was planned originally to supply water to a farm on the east bank of the Pecos River in the basin of the old Lake Surprise. The canal was afterwards extended nearly 10 miles, in one place widening out into a lake 1½ miles long and one-half mile wide, with an average depth of 30 feet. This lake was formed by a short dam, the canal being taken out at one end of the dam. This canal and lake have been abandoned for several years and the canal is used only as far as the Hagerman farm, a distance of perhaps 2 miles from the dam. The canal runs through sand dunes nearly all of its course and great difficulty is experienced in keeping it clear of drifting sand.

The Barstow and Pecos City system was originally planned to cover great tracts of the level land of the Toyah Lake basin. All of the irrigation on the west side of the river has been abandoned and the present system waters the east side around Barstow. The water is diverted from the Pecos without storage, taken out on the west side, flumed across to the east side, and distributed.

THE ROSWELL DISTRICT.

The Geology of the Roswell Area.

The Roswell area, lying as it does upon the junction of the Pecos and Hondo rivers, consists of more or less perfect terraces cut by these streams in the basin sediments which once filled the valleys of the

streams. Rock is not exposed, except in a few areas on the bluffs bordering North Spring River on the north. Here the gypsum of the plains to the north is exposed and in all of the soils of the Roswell sheet gypsum is found in some quantity, in places forming a pure gypsum subsoil, but of such a local nature and in such small areas that these points were not mapped. Crossing the North Spring River and Hondo bottoms the land ascends to the second terrace, upon which is nearly the whole of the farming district of Roswell. Above this is the upland prairie or third terrace—land too high to receive water from the spring rivers. There has been more or less intermixture of the soils of these terraces, but their general characteristics are well preserved.

SOILS.

The soils of the Roswell area have been classified under four types:

1. Pecos sandy loam.
2. Roswell sandy loam.
3. Roswell loam.
4. Hondo meadows.

These types are indicated in colors on the accompanying map. The lightest shade represents the upland terraces of Pecos sandy loam, and the deeper shades represent the Roswell sandy loam and the Roswell loam. The Hondo meadows are represented by a different color.

THE PECOS SANDY LOAM.

The Pecos sandy loam is a light loamy soil covering great areas of the prairie land above the canal and extending up the Hondo River along its terraces. This soil represents the uppermost terrace of the basin deposits. The boundaries of the soil and of the basin were not determined, but the basin is known to extend over a territory more than 15 miles in width from the Pecos and extending from the Hondo south nearly to Seven Rivers. The native vegetation consists of blue and black gramas, woollyfoot, a little mesquite and needle grasses, together with occasional cacti and yuccas. The plains are entirely unwooded with the exception of a row of trees along each side of the Hondo.

This great tract of plain has been little cultivated on account of the scarcity of water. A storage system on the Hondo has been planned which if ever carried out will irrigate thousands of acres of this beautiful upland soil. The area of the Pecos sandy loam was examined in several places for alkali. Borings were made along the line of the old stage road from Roswell to Carlsbad and a few borings 6 or 7 miles farther west. Within the top 6 feet of the soil very little soluble matter was present, but in some places below this point small quantities of salts occur—in some cases as high as 0.25 per cent. The following table shows the results of the examination of this soil:

Soluble salt content of Pecos sandy loam.

Depth.	181.	182.	183.	186.	189.	190.	192.	193.
Feet.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
1	0.09	0.04	0.08	0.07	0.07	0.07	0.08	0.06
2	.06	.06	.06	.11	.09	.09	.07	.07
3	.04	.10	.05	.11	.09	.09	.11	.26
4	.06	.22	.04	.07	.13	.11	.08	.32
5	.20	.20	.04	.07	.16	.12	.11	.33
6	.27	.17	.03	.10	.15	.13	.15	.30
7	.....	.....	.....	.....	.15	.....	.....	.24
8	.....	.....	.....	.....	.16	.....	.....	.21
9	.....	.....	.....	.....	.17	.....	.....	.22
10	.....	.....	.....	.....	.22	.....	.....	.53
11	.....	.....	.....	.....	.21	.....	.....	.....

There need be no apprehension that this quantity of salt will ever nage the lands where adequate drainage is either natural or is artiially provided. However, seepage waters may collect and damage e land. When water is applied in quantity to a great tract of level nd such as this, the seepage water is very apt to find difficulty in get-ng to the streams, and therefore collects until too near the surface of e ground for safety. This seepage water will also, without doubt, nage the lower lands and draws unless these are protected by derdrainage.

This area of Pecos sandy loam is underlaid only at a considerable pth by clay which will permit ready percolation of the seepage waters. is clay is exposed where the sandy loam has been removed, and is seen ll developed in the Roswell loam. A typical section of the Pecos sandy am, to a depth of 6 feet, would show a uniform loam throughout, so that is clay will not interfere with underdrainage should such be desired. The texture of this soil is represented in the following table:

Mechanical analyses of soils of Pecos sandy loam.

Diameter.	Conventional names.	4115. Roswell, 6 miles S.E. (0–12 inches).	4123. Roswell, 10 miles S.W. (0–24 inches).	4125. Greenfield, 10 miles W. (0–24 inches).	4126. Roswell, 10 miles S. (0–24 inches).	4128. Roswell, 12 miles S. (0–24 inches).
Millimeters.		*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
2 to 1	Gravel	.....	.....	.....	.....	.....
1 to 0.5	Coarse sand	1.11	Trace.	Trace.	Trace.	Trace.
5 to .25	Medium sand	2.55	3.95	1.52	1.22	2.05
25 to .1	Fine sand	14.12	16.45	9.15	6.97	9.76
1 to .05	Very fine sand	38.57	29	34.10	29.61	33.11
05 to .01	Silt	13.17	15.18	17.34	19.30	19.02
01 to .005	Fine silt	9.63	9.76	9.70	12.10	10.35
005 to .0001	Clay	13.62	17	18.45	21.90	13.77
Loss		1.60	3	1.85	1.46	1.46
Loss at 110° C		2.70	3.30	5.28	4.98	4.59
Loss on ignition		2.75	3.30	3.85	3.94	4.55

[a] Dissolved in 1½ liters of water used in mechanical analyses, mainly gypsum.

The mechanical analysis of this soil, when first made by the customary ethod in this division, showed as much as 30 per cent clay. This difred so much from the field observations, for in the field these soils ere classed throughout as sandy loams, that the source of the differ-

ence was investigated. A microscopical examination of the soils showed them to be composed of small conglomerations of clayey matter cemented by carbonate of lime. By agitation with large quantities of water this carbonate of lime was partially dissolved, the clay loosened, and the resulting analysis would make the soil appear heavier than the field judgment would warrant; also it was found that there was a quantity of matter in the soil which dissolved in the water used in the analysis. This was not in all cases alkali, but was more likely to be gypsum and carbonate of lime, both of which are slightly soluble in pure water. This soluble matter is always included in the clay by the method employed in the analysis, and thus served to make the soil appear heavier than it really was. This soluble matter was determined in all cases and subtracted from the clay. The amount of soluble matter is given, but must not be confused with the alkali determinations given in other tables.

The action of water upon this soil in the field produces nearly the same results as were observed in the laboratory, and where irrigated a difference can be seen in the apparent clay content of the soil. After irrigation continued for some time the sandy loam changes in appearance and character to a loam or even to a clay loam.

THE ROSWELL SANDY LOAM.

This soil differs from the Pecos sandy loam in being a little heavier though the top foot of soil may be nearly of the same texture. It is underlaid at from 1 to 2 feet by a loam, and this in turn is underlaid at 5 feet by a clay loam or clay.

The native vegetation of this soil was originally the same as on the Pecos sandy loam, but since irrigation water has been applied all waste tracts are now covered with salt grass and alkali weeds.

The texture of this soil in the field was considered different from the soils of the prairies. The difference was so slight that the results of the mechanical analysis fail to show it, as appears from the following table; still the mechanical analysis is not considered perfectly reliable in these soils for the reasons stated above.

Mechanical analyses of soils of Roswell sandy loam.

Diameter.	Conventional names.	4099. Roswell, 3 miles SE.	4108. Roswell, 5 miles E.	4112. Roswell, 5 miles SE.
Millimeters.		*Per cent.*	*Per cent.*	*Per cent.*
2 to 1	Gravel	.....	.....	.....
1 to 0.5	Coarse sand	0.35	.....	Trace.
0.5 to .25	Medium sand	1.90	.40	2.20
.25 to .1	Fine sand	15.87	12.40	17.80
.1 to .05	Very fine sand	30	32.80	34.22
.05 to .01	Silt	14.83	15.65	14.46
.01 to .005	Fine silt	8.90	10.22	8.03
.005 to .0001	Clay	15.66	15	17.10
Salts dissolved in 1½ liters of water used in mechanical analysis, mainly gypsum		1.74	4.50	1.60
Loss at 110° C		3.13	3.40	2.61
Loss on ignition		7.15	6.25	3.60

There is little question but that the arrangement of the soil grains lays a great part in the field judgment of the texture. The application of the irrigation water separates the flocculeS and to a small extent ives the soil a much heavier appearance than the mechanical analysis hows. This fact is plainly to be seen in the Pecos Valley soils

The Roswell sandy loam may be considered the same as the Pecos andy loam, with the upper part of the stratum removed, bringing the am and clay nearer the surface. Since the alkali is more abundant in he lower layers of the Pecos sandy loam, it is evident that the salt hould be more abundant in the Roswell sandy loam, which represents he lower strata of the Pecos sandy loam. Such was, no doubt, the case, hough it has been found difficult to secure a sample of this soil which as not been irrigated. The following table represents the soil as near s original condition as it is possible to find:

Salt content of Roswell sandy loam before irrigation

Depth.	67.	Depth.	67.
Feet.	*Per cent.*	*Feet.*	*Per cent.*
1	0.07	5	0.36
2	.27	6	.25
3	.44	7	.20
4	.54	8	.20

After irrigation water has been applied to this soil a very different tate of affairs is found to exist. The greater part of the soluble matter s dissolved in the irrigation water, and should this water be able to ink into the lower subsoil and flow off into the country drainage, most f this salt would be entirely removed from the soil and do no further amage. This soil, however, becomes heavier and more compact in its ower strata, and consequently the percolating water finds difficulty in enetrating to the stream channels. Thus accumulations of water ollow and evaporation from the surface of the soil concentrates the oil moisture near the immediate surface of the ground. The salt either rystallizes out onto the surface of the ground or diffuses down into the oil slowly. If this state of affairs is allowed to go on unchecked the urface of the soil becomes too saline for agricultural plants to grow nd the soil is abandoned to salt grass and other alkali vegetation.

The accompanying table shows the conditions found to exist in such oils after unchecked evaporation from a wet soil.

Soluble salt content of Roswell sandy loam after irrigation.

Depth.	135.	142.	27.	54.	144.	47.
Feet.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
1	0.09	0.06	0.45	0.66	0.16	0.41
2	.15	.06	.18	.44	.13	.52
3	.28	.10	*a*.30	.52	.12	.48
4	.26	.14	.15	*a*.47	.10	.42
5	.32	.18	.17	.38	*a*.10	.39
6	.34	.18	.17	.33	.....	*a*.35
7	.....	.....	.....	.....	.....	.36

a Water encountered.

Samples 135, 142, 144 illustrate soils in which water is not standing near the surface. Here the original salt has been washed down and away through the subsoil. In the other samples water has accumulated in the subsoil, and at the time examined stood at the depths noted. Through fluctuation in the level of this water table, the standing water at other seasons approaches much nearer the surface.

A general relation is to be seen between the depth to standing water and the amount of alkali within the surface foot of soil. The amount of alkali within the surface foot is the controlling factor in the cultivation of these soils; and, since agricultural plants refuse to grow with ½ of 1 per cent alkali, the evaporation from the surface has already damaged some of the soils referred to in the table.

ROSWELL LOAM.

This soil differs from the Roswell sandy loam in having the clay near the surface. A typical section shows about 4 feet of loam underlaid by heavy loam and clay.

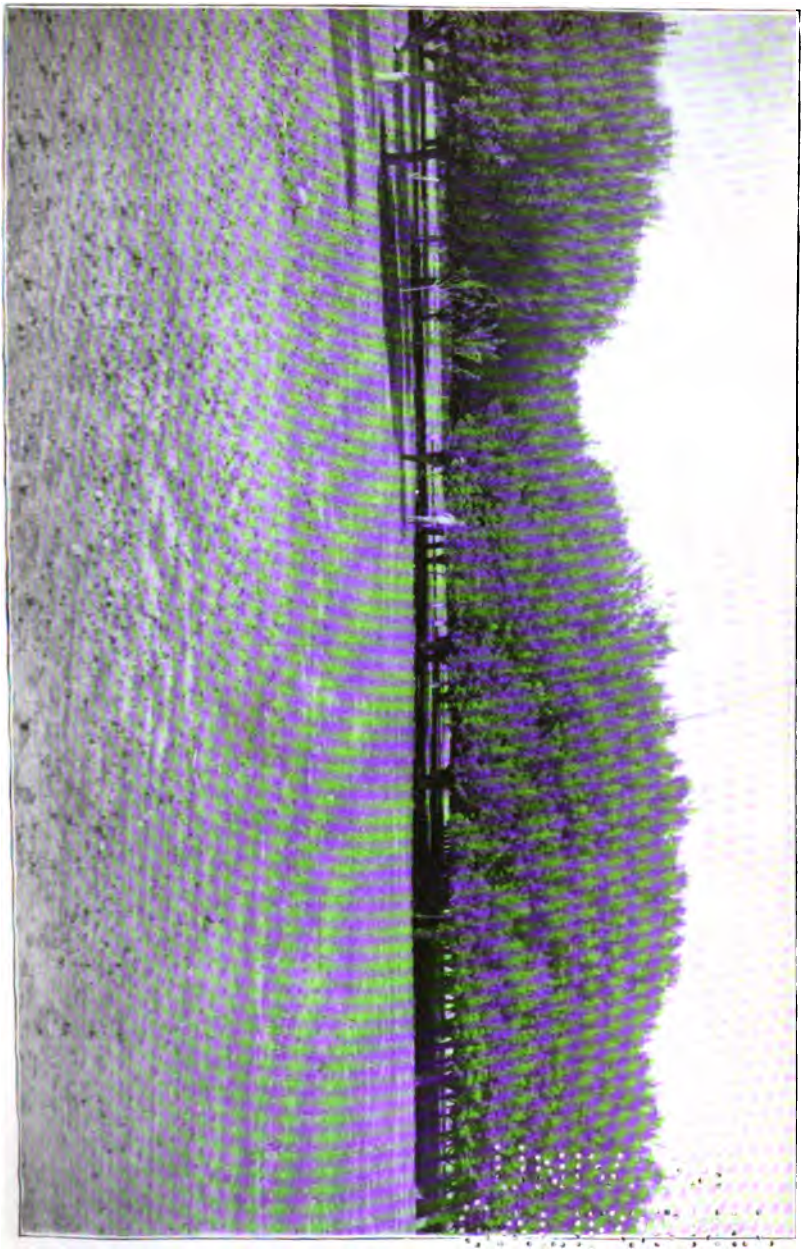
The Roswell loam is represented on the soil map by an area in the center of the Roswell sandy loam. This area is underlaid by impervious clay throughout, and, wherever it has been watered without proper drainage, water can usually be found at a depth of from 3 to 5 feet. The conditions of this soil with reference to alkali are nearly the same as in the Roswell sandy loam, but wherever evaporation has been allowed to progress unchecked the surface soil is at present charged with alkali. In some places this has gone on to such an extent that the soil should be classed as an alkali flat.

Soluble salt content of Roswell loam.

Depth.	33.	34.	39.a	41.	48.	49.
Feet.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
1	0.19	b1.34	1.69	2.76	0.42	0.72
2	.15	.45	.60	.93	.28	.36
3	c.22	.31	.43	1.14	c.22	c.31
4	.35	.31	.32	1.04	.20	.31
5	.36	.33	(c)	1.25	.16	.34
6	.36	.29	.....	c1.04	.14	.32
8	.....	.....	.....	.72	.....	.....
10	.....	.....	.....	.44	.....	.....
12	.....	.....	.....	.32	.....	.....

a Never irrigated. b Water at surface. c Water encountered.

Sample No. 33 represents the soil in nearly its best condition as regards alkali, but with standing water too near the surface. The texture of the Roswell loam in the field was classed as heavier than the Roswell sandy loam, though mechanical analyses of a few samples show very little difference. This again illustrates the difficulty of interpreting the texture of a soil from a mechanical analysis alone. The change in arrangement of the soil particles by the action of irrigating waters and the presence of the clay nearer the surface give the impres-



OLD APPLE ORCHARD, 5 MILES SOUTHEAST OF ROSWELL, N. MEX.

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sion in the field that the Roswell loam is a heavier soil than the Roswell sandy loam or Pecos sandy loam, and it has been so classed. This shows that the holding power and its penetrability to water are often important factors in determining the character of a soil as well as the size of the grains.

THE HONDO MEADOWS.

Under the title of Hondo Meadows are included the low-lying lands along all of the streams, but, with the exception of a narrow strip along part of the South Spring River and a small part immediately along the Pecos, these meadow lands on the soil map are all along the Hondo River and around its junction with the Pecos. The term *meadow* is used in the same sense as in humid regions, and means low land, naturally wet from the proximity of the stream, though in the arid climate of the Pecos Valley the low-lying lands need not necessarily be wet before irrigation.

The soil of these meadows is formed from recent alluvium, and in its physical properties represents this mud, being heavy and silty. A typical section of the Hondo meadow land shows 3 feet of clay loam underlaid by clay.

The water of the Hondo is very muddy, and when fields are flooded with this water a thin deposit is left. The fertilizing value of the silt in suspension is considerable; in fact an analysis shows it to contain more plant food than the mud of the Nile River in Egypt.

Chemical composition of Hondo and Nile sediment.

	Hondo mud (Skeats).	Nile mud (Mackenzie).
Insoluble matter and silica	43.6	58.17
Iron oxide and alumina	21.4	24.75
Oxide of manganese		.09
Magnesia	2.1	2.42
Lime	5.7	3.31
Potash	1.19	.66
Soda		.62
Sulphuric acid	1.96	.20
Phosphoric acid	.3	.21
Carbonic acid		1.55
Organic matter	9.8	8.00
Nitrogen in organic matter	.32	.12

The application of water containing this mud can not but be of benefit to most lands in the valley. Its wealth of plant food is above that of the ordinary soils, and the nitrogen it contains should be of special value. The sediment often amounts to as much as 10 per cent by volume of the water, it is stated.

This analysis may be taken to represent the composition of the Hondo meadow soil. This soil is the richest in plant food of all the soils mapped. The sediment of the river represents the richest portion of the soils of the upper valley.

From the position of these lands, subject to weathering from below by seepage waters from the higher lands, the evaporation from the surface of the soil has accumulated quantities of salt within the soil and at present nearly the whole of this rich land is given over to salt grass. Cultivation has been attempted at several points and the effect of underdrainage on the soils is readily noticeable. On section 33, one-half mile east of Roswell, a truck patch has been laid out on the Hondo bottom. Near the bluffs sloping from the second terrace to the bottoms the land is wet and alkaline and the growth of tender truck crops uncertain or impossible. Toward the bank of the Hondo, which at this point is cut down 8 feet below the level of the meadows, the soil is better drained and truck crops do well. Should drains be cut from the river back to the bluffs at intervals, the water seeping out from the uplands would be drained away and the salt already in the bottoms could be washed into the Hondo and so carried away. On section 34 an alfalfa field is growing on the Hondo flats. Along the foot of the bluffs, 150 yards from the river, the soil is wet and boggy, with salt grass the only vegetation. Close by the stream banks, however, the growth of alfalfa is heavy and luxuriant and grades down until, less than 100 yards from the escarpment of the terrace, it fails entirely to grow.

Perhaps the best illustration of the effect of drainage is seen upon the farm of Mr. Charles Bremond, on section 31. Here the Hondo makes a bend, and close to the river all around the bend the soil is in far better condition than farther back. The mechanical analysis of the Hondo bottom land shows it to be a much heavier soil than any other exposed in the valley. The sediment as originally deposited contains very little more clay than the Roswell loams, but from its position, being wet nearly all of the time, the soil particles break down and a much heavier soil is formed. The two analyses in the table represent the two conditions of the soil—the first column representing the sediment immediately after its deposition and the other soil formed from the weathering of this sediment.

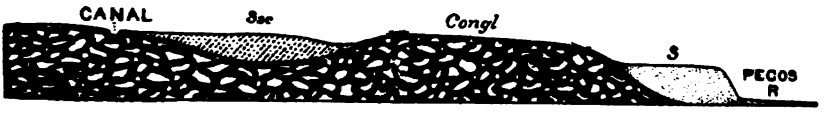
Mechanical analyses of soils of the Hondo meadows.

Diameter.	Conventional names.	4145. Roswell, 3 miles E.	4119. Roswell, 1 mile E.
Millimeters.		*Per cent.*	*Per cent.*
2 to 1	Gravel		
1 to 0.5	Coarse sand	Trace.	
0.5 to .25	Medium sand	1.46	0.76
.25 to .1	Fine sand	5.58	4.85
.1 to .05	Very fine sand	21.04	10.65
.05 to .01	Silt	35.69	12.35
.01 to .005	Fine silt	7.13	17
.005 to .0001	Clay	14.52	34.65
	Salt dissolved in mechanical analysis.	.95	5.40
	Loss at 110° C.	5.57	7.47
	Loss on ignition	7.89	8.63

Figure 1 gives sections through Roswell, Carlsbad, Otis, and Florence and shows the relation of the soil at the different parts of the valley.

SECTION THROUGH ROSWELL

SECTION THROUGH CARLSBAD



SECTION THROUGH OTIS

SECTION THROUGH FLORENCE

FIG. 1.—Sections in Pecos Valley, New Mexico.
(*S* = sand; *Ssc* = sandy loam; *Sc* = loam; *Scc* = clay loam; *C* = clay; *Congl* = conglomerate; *Gyp* = gypsum.)

WATER SUPPLY.

The water supply from the North and South Spring rivers is good; that is to say, it does not contain enough salt to be harmful to vegetation in any way. The average water contains 75 parts of soluble matter to every 100,000 parts of water. About 49 parts consist of calcium carbonate (limestone) and calcium sulphate (gypsum), which are harmless to plants and crystallize out upon evaporation of the water. The remaining 26 parts consist of salts readily soluble in water and such as are likely to remain in solution and accumulate to such a degree as to be harmful.

The following analysis by Prof. E. M. Skeats, of Carlsbad, represents the average chemical composition of the salt dissolved in the water:

Chemical composition of the North and South Spring rivers, in parts, per 100,000 parts of water.

$NaCl$	8
$CaCO_3$	18
$CaSO_4$	20
$MgSO_4$	16
K_2SO_4	2
Silica, alumina, and iron	1
Water of crystallization, etc	10
Total solids	75

Since most of our agricultural plants are able to grow with their roots in solutions containing as much as 1 per cent of these readily soluble salts, it would require evaporation and concentration of the Spring River water to one-fifteenth of its bulk in order to kill vegetation. Such a concentration can easily be avoided within the soil. By the application of 1 acre-foot of this water about 700 pounds of harmful salts are added, and, since 15,000 pounds per acre-foot can be taken as the maximum amount of salt allowable for plant growth, it would require nine years' accumulation of irrigation waters, allowing 2½ acre-feet of water for each year, and supposing none of the salt washed out of the land. Such a condition could hardly exist, for a certain percentage of the salts is washed down below the first foot. Moreover, part of the salt is annually removed in the crop. Four-tenths of 1 per cent of soluble salt in a soil capable of holding, when saturated, 40 per cent by weight of water gives a concentration of 1 per cent in the soil moisture when the soil is saturated.

Underground Water.

One of the maps accompanying this report shows the depth to standing water during June, 1899. The depth is shown by three shades of green, the lightest shade showing land in which water can not be found by boring 10 feet. The intermediate shade shows land in which water is to be found between 3 and 10 feet in depth. Such land as this, if the water approaches the higher limit, is in danger of becoming too wet and the level of the water table should be carefully watched; and, if it rapidly approaches 3 feet, drainage must be furnished to prevent the water from rising above 3 feet. The reason for giving this land a special tint is that it is approaching the limit, and may need drainage. The darkest tint shows land which is at present in need of drainage, for at the time it was examined water was found within 3 feet of the surface. For such land there can be no question but that its great need is underdrainage. Few plants, none of which are used as agricultural plants in the Pecos Valley, are able to grow to advantage with their roots immersed in water for more than a day or two at a time, and, as most of our common plants send roots as deep as 3 feet, the level of standing water should be kept below this level. Particularly is this true of arid regions, where there is not so much difference between soil and subsoil as in the East. Alfalfa, which is the most important crop of the Roswell area, sends its roots to great depths. Cases have been noted where the alfalfa grew luxuriantly for two or three years, but suddenly began to sicken and die. Investigation proved that the plants grew all right until the roots reached the water table. Here, in their effort to reach farther into the subsoil, the roots were partly immersed in standing water and the crop suffered.

The scale upon which this map is printed does not permit detailed representations of each section of land. There are no doubt small spots

within the area shown as in need of immediate drainage which are at present in fair condition for crop production. The map is intended to show in a general way the conditions found existing during June, 1899, and must not be interpreted as representing the conditions at any other time. The entire condition of the land may change with the seasons, and during some other season of the year the water level may be very different. On the map all of the lands below the irrigating canals have standing water at less than ten feet. Such is generally true, though there are a few isolated points immediately along the bank of the Hondo, or under some land never irrigated where water stands at a greater depth than ten feet. Throughout the greater part of the Roswell loam, where clay is found near the surface of the soil and in the draws and close to the river channels, the land is wet and water stands at less than three feet.

The Alkali of the Soils.

One of the maps accompanying this report shows the conditions of the ground with reference to alkali. The three colors indicate the amount of alkali in the soil; soil containing from 0 to 0.25 per cent of alkali; soil containing 0.25 to 0.50 per cent, and soil containing over 0.50 per cent. Or the map shows (1) the areas of land which are free from harmful quantities of alkali; (2) the lands which contain harmful quantities of alkali, but not enough alkali to prevent the growing of crops; and (3) the lands which contain too much alkali for cropping.

The term alkali, as used throughout the West, designates any soluble matter in a soil or water. The term does not mean that the salts are alkaline or basic in a chemical sense, for the greater part of these salts are neutral, and in some cases even acid salts have received this name. There are two kinds of "alkali" commonly recognized, (*a*) white alkali and (*b*) black alkali.

The white alkali is composed of one or more of the following salts, named in the order of their importance: Sodium chlorid, sodium sulphate, magnesium sulphate, calcium chlorid, magnesium chlorid with, in some districts, borates and nitrates. The essential constituent of black alkali is sodium carbonate, though this salt is never pure, but is mixed with sodium bicarbonate and the salts which form the white alkali. These salts are formed through the weathering of the rocks, and in districts of light rainfall the amount of seepage through the soil is insufficient to wash them away. There is therefore an accumulation in most arid soils—the amount, other things being equal, varying inversely as the rainfall of the district.

In some places the alkali is the accumulated salt from the evaporation of inland lakes. All river water contains soluble matter, and when this water enters an inclosed basin where the waters evaporate an accumulation of salts is the result. The muds, silts, and sand left by this lake all contain soluble matter, and upon applying water by irrigation to such soils the alkali, which may not be apparent on the surface

of the soil, is brought to the surface by the water, as it rises through capillary attraction. These inclosed basins sometimes represent the most difficult conditions with which the farmer has to deal, for the salt commences to accumulate in the lowest portions of the basin and extends up the sides of the basin as the amount of salt brought in increases. The great expense or even impossibility of draining such basins is the great barrier in the way of their reclamation. The Great Salt Lake of Utah is the remnant of a great lake, and its waters to-day represent the mother liquor from the concentration of great quantities of water.

In past geological ages arms of the ocean were sometimes cut off from the main ocean and the waters concentrated by evaporation until part or all of the burden of soluble matter was deposited. Beds formed in this way to-day, when elevated above the level of the sea and exposed to erosion, give rise to quantities of alkali. The Red Beds, forming the great plains north of Roswell in the Pecos Valley, and underlying the Staked Plains to the east, were deposited in this way, and though no beds of salt are found, yet all of the soils from this formation contain soluble matter. Beds of gypsum were deposited, thus indicating that the ocean water was concentrated by evaporation. Included within this gypsum are small quantities of soluble salt. If beds of these salts were ever deposited, the greater part has been removed by solution, for to-day no deposits of salt within this formation in New Mexico have been found, so far as known.[1]

Another source of alkali in the Pecos Valley is from the decomposition of volcanic rocks. To the west of the Pecos great areas of apparently recent lava are found, and associated with the lava are alkali springs of varying degrees of concentration. Some of the deposits of gypsum in the Pecos Valley can be accounted for only on the assumption that the gypsum is the result of the action of acid waters upon the limestone. Even though the lava flows were not associated with alkali springs, the decomposition of the igneous rocks would give rise to the formation of alkali salts, and without doubt the igneous rocks west of Roswell are the source of parts of the alkali salts.

The alkali of the Roswell area is entirely the white alkali, as far as observed. Many spots were pointed out as being due to the black alkali, but they were undoubtedly due to calcium chlorid. Sodium carbonate can hardly exist under the prevailing conditions.

It has been pointed out by Hilgard that gypsum is an antidote for black alkali under certain favorable conditions. If the soil be well drained and aerated, the black alkali, sodium carbonate, in contact with the gypsum is more or less completely converted into the less noxious white alkali, sodium sulphate. The reaction may be expressed thus:

$$Na_2CO_3 + CaSO_4 = Na_2SO_4 + CaCO_3$$

[1] Since this was written it is reported that a bed of rock salt over 400 feet deep has been encountered in boring for an artesian well at Carlsbad.

On the other hand, if the soil be not well drained, that is to say, conditions exist favorable to the retention of carbon dioxid and moisture, a reverse reaction will predominate, which may be indicated thus:

$$Na_2SO_4 + CaCO_3 + CO_2 + H_2O = Na_2SO_4 + H_2Ca(CO_3)_2 = 2\,H\,NaCO_3 + CaSO_4$$

and the sodium bicarbonate ($H\,NaCO_3$) being a very instable compound, always inverts to some extent with the formation of sodium carbonate ($Na_2\,CO_3$), the undesirable constituent of black alkali.

Somewhat similar reactions take place when gypsum comes in contact with chlorids in solution or in a wet soil. Calcium chlorid and sodium sulphate will be formed, which is indicated thus:

$$2\,NaCl + CaSO_4 = Na_2SO_4 + CaCl_2$$

There will now be present in the solution, sodium chlorid, calcium sulphate, sodium sulphate, calcium chlorid, as well as the ions formed by the dissociation of these salts. If the soil be well drained and sufficient water drains through it, the soluble salts thus formed are rapidly leached away; but if the soil be not well drained, that is to say, if it contains standing water near the surface, there will be a gradual evaporation of the water with a concentration of its salt contents. At first sight it would appear that the calcium sulphate, being so much less soluble than the other salts, would be precipitated as a solid before any of the other salts; more and more being formed from the sodium sulphate and calcium chlorid and precipitating in turn. But this process will take place, if at all, to a much less extent than is generally supposed. It is to be remembered that the solution is becoming more and more saturated with respect to the sodium chlorid. It follows, from the investigations of Treadwell and Reuter, and from experiments in this laboratory, which will be described later by Dr. Cameron, that the amount of gypsum dissolved—its constituents being held in solution as calcium chlorid and sodium sulphate—is very greatly increased with the concentration of the sodium chlorid.

It thus comes about that as evaporation proceeds the solution is actually becoming richer and richer in the very soluble calcium chlorid, and finally it separates as such along with or after the other readily soluble salts. On resolution, being much the most soluble of the salts in the mixture, it would be the first to dissolve, and from the fact that it has a common ion with sodium chlorid, would retard the solution of that otherwise very readily soluble salt. It would increase the solubility of the less readily soluble sodium sulphate if it remained in contact with it sufficiently long for equilibrium to take place. But if it is quickly brought to the surface by capillary forces, or by diffusion, and then quickly concentrated by rapid evaporation, there would be a concentration of the calcium chlorid in the upper portions of the crust.

In several spots in the Pecos Valley considerable quantities of cal cium and magnesium chlorid were found in the *crust* on the soil. It probable, as will be seen from the above reasoning, that but sm quantities would be found at any depth in the soil itself. These crus containing calcium chlorid have a dark appearance quite similar to th true black alkali. Indeed, they are locally known as black alka though their characteristic feature is the presence of much calcium a magnesium chlorid, not that of sodium carbonate. The reasons fo this blackened appearance are not obvious, and the evidence at hand is too meager to warrant any suggestion at present. It is worthy o note that these spots are of necessity damp or wet—a condition favo able to the formation and retention of carbonic acid. But it will require further investigation to say definitely whether this be a factor in the production of the observed results.

Analyses of alkali crusts from the Roswell area.

No.	Locality.	Calcium sulphate.	Magnesium sulphate.	Sodium sulphate.	Sodium chlorid.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
4092	Sec. 35, T. 10 S., R. 23 E.	14.17	28.05	47.99	9.82
4093	Sec. 35, foot of gravel hill	9.09	38.42	41.15	11.33
4097	Bremond crust	13.58	15.78	35.77	34.89
4107	Black crust, Bremond	6.85	12.86	50.90	29.41
4139	High spot, Michelet	45.57	17.53	1.44	35.46
4149	Tule crust, E. of Northern canal	4.03	21.64	64.77	9.57

Of the salts shown in these analyses sodium chlorid is the most harmful to plants. It is generally stated that most agricultural plants can grow with 0.25 per cent within the surface foot of the soil, while of the sodium and magnesium sulphate plants can withstand as much as 0.50 per cent. Observations upon the growth of alfalfa in the Roswell soils showed that it was just able to grow when from 0.40 to 0.50 per cent of alkali was present. The figure 0.50 has been taken as the maximum limit, and though plants are able to grow with this amount of salt in a soil the growth is uncertain and light, in fact 0.25 per cent damages crop growth to a great extent. This range is, therefore, taken as the danger limit.

The action of soluble matter within a soil upon the growth of plants is very complex and to a great extent not well understood. It is a fact of common note that a *little* alkali makes crops grow better. There is danger in this little alkali, however, for if the amount increases ever so little beyond the point where plants grow better, there is noted a decrease in production and the productivity of these soils may be considered dependent upon the per cent of alkali present. The fact has been noted that with 0.25 per cent of alkali in the top foot of soil the crop production is decreased. This decrease becomes more and more marked until the plants refuse to grow. The limit of growth may be considered 0.50 per cent. Occasional cases have been noted elsewhere where crops would live with more alkali present, but in the Pecos Valley, soils, with one-half of 1 per cent alkali, are entirely unproductive.

Plants of different species are able to withstand different amounts of alkali, and the resistance of the same plant to alkali varies in different stages of its growth. In the Roswell area alfalfa was found sickly and dying with a little over 0.40 per cent alkali in the soil, while in other stages of its growth isolated plants have been found growing in a soil containing more than 0.75 per cent alkali. Young apple trees showed signs of distress with a little over 0.30 per cent, while sugar beets grew with something over 0.50 per cent.

The action of soluble matter upon plant growth varies with the osmotic pressure of the solution in the plant tissues. This fact has been experimentally demonstrated by Slosson and Buffum of the Wyoming Experiment Station. Since the osmotic pressure varies with the concentration of the solution, the mere statement of the total percentage of salt within a soil determined chemically does not give a true idea of the osmotic pressure of a solution. The percentages as given in this report and in all reports of the Division of Soils are based upon the dry weight of the soil and are the amount of alkali dissolved by the water when the soil is saturated.

The method for salt determinations as used in the field work of the Division of Soils has been described in previous publications, but a short sketch of the method will be given here for the intelligent consideration of the results.

Samples of soil are collected with a 1½-inch soil auger with an extension handle long enough to bore 20 feet. The samples are usually taken in 1-foot sections and the alkali determined in each foot of depth. The soil as collected is thoroughly mixed upon a clean piece of oilcloth. A portion of the mixed sample is saturated with distilled water and packed in a hard-rubber cell of a capacity of about 50 c. c. with two metal sides. The electrical resistance of this saturated soil is taken by a Wheatstone bridge. The temperature is then taken by inserting a thermometer in the soil in the cell. This constitutes the field work. In the laboratory a number of typical samples of the alkali in the soil are analyzed and a solution of salt corresponding in relative composition to the average of these analyses is made. By varying dilutions of this solution the per cent of salt is ascertained for each 5 or 10 ohms difference in resistance. The per cent of water of saturation for each type of soil is then determined by saturating the soils in the same manner as done in the field and making gravimetric moisture determinations. Then by determining the weight of the wet soil the cell will hold, the number of cubic centimeters of the soil moisture in the cell filled with saturated soil may be calculated. Knowing the number of cubic centimeters of soil moisture contained in the cell full of saturated soil, the cell factor, or the figure by which the resistance of that amount of solution must be multiplied in order to give the specific resistance, can be found from the known constants of the cell. The resistance obtained in the field is multiplied by the figure 0.55 to correct for the resistance offered by the insoluble, nonconducting particles of soil and the result multiplied by the cell factor, giving the

specific electrical resistance of the solution around the soil grains. The per cent of salt corresponding to the specific resistance is determined from the solution made up from the chemical analyses of the field samples. This percentage, multiplied by the per cent of water in the saturated soil, gives the per cent of alkali in the dry soil.

In the field work borings are taken at frequent intervals and the salt content determined for each foot of depth. These percentages are plotted on base maps and lines drawn separating the three conditions of the soil respecting alkali. These three conditions are shown in the alkali map by different colors.

The maps as presented may be taken as an indication of the condition of the soil during June, 1899. For the construction of the maps the salt content of the soil to a depth of 5 feet was considered.

The area of Pecos loam is seen to be colored to indicate between 0.25 and 0.50 per cent alkali. This soil at every point examined within the area of the map was found to contain more than 0.25 per cent of alkali within the upper 5 feet. The porosity of this soil, however, would enable most of this salt to be immediately washed out upon the application of irrigation water, as has been seen in a number of places where small tracts of this upland soil were cultivated around Roswell.

The areas on the salt map showing from 0.25 to 0.5 per cent of salt are susceptible of a much greater range of conditions than are indicated by the range in salt content to the depth of 5 feet. Crops may make a moderate growth on any or all parts of this class of land, and there are places near the lower limit, undoubtedly, where the conditions are excellent at the present time, because the salts are so distributed that only small amounts are contained in the first and second foot, while a sufficient amount occurs below this to bring the average up to 0.25 per cent or more.

This condition, while giving excellent results at present, is dangerous, because the salts are liable to move toward the surface unless good underdrainage is provided.

As we approach the upper limit on this class of land the other extreme may be found to exist, i. e., an accumulation of salts at the surface in sufficient amount to kill all crops, and yet the quantity of salts be sufficiently small in the lower depths to bring the average for 5 feet below 0.5 per cent.

The Problems of the Roswell Area.

It has been shown under the discussion of the soils that the accumulation of the alkali salts in the surface of the soil is in all cases due to lack of drainage. The salts which are present now near the surface were once buried at such a depth as to be of little or no damage to plants, and this translocation has been brought about by irrigation. The water supply is good; therefore the salt must originally have come from the soil. Much of the land has already suffered from accumula-

ıs of salt, so there are two important problems before the farmer: st, the prevention of further damage from seepage water and ali salts; second, the reclamation of the lands already damaged or ındoned.

Roswell is situated in a large grazing country, and the principal ustry is cattle and sheep raising. The agriculture is largely supmentary to the range. Alfalfa is the principal crop. There is, how:r, a growing tendency toward fruit raising on the part of some of farmers. The local demand for fruit is great enough at present to all of the fruit produced, but there is danger of overstocking the al market, and thus necessitating the shipment to distant markets. situated as it is, there is no question but that cattle and sheep will ve the most profitable industry toward which the farmers may turn. e success of the Roswell community is to be attributed to their lization of this fact. Since alfalfa offers the most ready forage crop, soil should be in the best condition for its growth. One of the st essential conditions of a soil in an alfalfa field is good drainage. falfa roots penetrate deep into the subsoil, and as soon as standing ter is encountered their roots cease to grow. If drainage keeps the el of standing water down, the success of the crop is insured. Drain- e also removes and insures no further damage from alkali.

THE HAGERMAN AREA.

GEOLOGY AND TOPOGRAPHY.

The Hagerman area, or Northern Canal system, lies about the center the basin formed by the ancient obstructions in the Pecos River ıout Seven Rivers. The Roswell area lies near the northern end of e same basin. This basin, cut out of the Red Beds or Permian strata, more or less filled with sediment derived from these rocks. The Red eds contain crystals of gypsum scattered throughout their sands and avels, and, interstratified with the beds of sand and clay, heavy, assive saccharoidal gypsum. It is to the solution and redeposition of is gypsum that the gypsum of the soils of the Roswell area is mainly ie, though this gypsum in the soils may in part be from mechanical idimentation.

The Hagerman area lies along the terraces cut by the Pecos River in ie sediments of the old lake. The action of the Pecos has been aided y the streams entering from the west, notably by the Felix and 'eñasco. The terraces are very imperfect, the land sloping from the dge of the river channel gradually upward to the west. On the east ide the Pecos is bounded by high bluffs.

SOILS.

The soils of the Hagerman district correspond very nearly to the oils of the Roswell area. On the lowest lands lying close to the Pecos River dune sands and sandy loams form the predominating soil types. These are usually well drained from their nearness to the river chan- el, though occasionally, even when apparently in the most favorable

conditions, these lands are found wet and in need of drainage. On t level lands immediately around Hagerman, the soil is heavy and co sponds very nearly to the Roswell loam. Around this are areas gypsum soil, which is exposed in drains to the south of Hagerm The discussion of the cultivation of this gypsum land will be defer until it is considered under the Carlsbad area, where it is more ty cally developed.

Upon the uplands of the Hagerman area and above the canal Pecos loam, similar to the upland soil at Roswell, is typically dev oped. This area of soil is a continuation of the Roswell area. soil map has not been drawn of the Hagerman area, as a short ti only was spent in reconnoissance of the soils. The great similarity this district to the Roswell and Carlsbad soils, however, will ena the conclusions drawn from them to be readily applied to the Ha man conditions.

THE WATER SUPPLY.

The Northern Canal heads in a dam across the Hondo River direc east of Roswell. This dam collects and directs into the canal th unused and waste water from the Berendo and North Spring rive also from the Hondo in times of flowing in that stream above Roswell. A great deal of seepage and drainage water is collected, which, togeth with the salt from the Berendo water, renders the Northern Canal wate salty. At the point where the Northern Canal crosses the South Spring River a second diverting dam collects the water of that stream. This also contains quantities of seepage and drainage water. The average condition of the Northern Canal water is shown by the following analysis by Prof. E. M. Skeats, of Carlsbad, N. Mex.

	Parts per 100,000.
NaCl	65
$CaCO_3$	17
$CaSO_4$	51
$MgSO_4$	25
K_2SO_4 } Na_2SO_4 }	23
Silica, alumina, and iron	2
Water of crystallization	19
Total solids	202

Of these salts calcium carbonate, calcium sulphate, the silicon, iron, and alumina compounds, with much of the water of crystallization, amounting in all to 89 parts, may be disregarded, since upon the evaporation of the water these compounds crystallize out and do not collect in the soil in sufficient quantity to be of harm to vegetation. Thus the harmful salts of the water are present in the proportion of 113 parts of salt to 100,000 of water.

UNDERGROUND WATER.

The wells above the canal are from 60 to 100 feet deep, with water at about 60 feet. The water in all of these wells is good, containing about

parts of soluble matter per 100,000. Of the land below the canal, rt of it has already become so wet that underdrainage is necessary. ound the town of Hagerman water is found in places as near the face as 3 feet. During the four years during which irrigation has en practiced the entire character of the vegetation around Hager- n has been changed from grama and other prairie grasses to salt ass. The change has been brought about almost entirely by under- ound seepage waters and alkali.

ALKALI OF THE SOILS.

The condition of the soils of the Hagerman area correspond exactly the conditions existing at Roswell. The cause of the present condi- ns, however, includes one factor which was noted as unimportant in Roswell area; that is, the amount of alkali in the irrigation water. e application of each acre-foot of Northern Canal water adds 3,000 unds of salts to the soil. Such salts, if allowed to accumulate by aporation of the water, would soon so impregnate the soil with alkali at crops would not grow. Allowing 2½ acre-feet per year, in two years ,000 pounds of soluble matter would have accumulated, or enough to event profitable cultivation, provided all of the salt was retained by e surface foot of soil. This rapid accumulation may easily be pre- nted by washing the accumulated salts from the previous irrigation wn into underground drainage. Another successful method is to ow soil-shading crops which prevent the rapid evaporation from the rface of the soil, so that less water is needed in irrigation. Cultiva- n offers the most effective method of preventing evaporation from e soil's surface, and this should be carefully followed out in the owth of all crops which allow cultivation.

PROBLEMS OF THE DISTRICT.

The problems of the Hagerman district are very similar in character the problems of the Roswell district. The accumulation of alkali alts must be prevented, and the excess already present must be emoved. The leakage from canals and laterals, particularly in the ase of water containing alkali salts, is one of the most potent sources f trouble. The loss from the canal in running through the sandy and ravelly soils is great. In the case of the main canal 1 cubic foot per econd is lost for every mile. This water, seeping under the ground, radually fills up the subsoil until capillary force lifts the water to the rface, where it evaporates leaving the alkali.

CARLSBAD AREA.

GEOLOGY.

The Carlsbad area lies entirely in Eddy County, New Mexico, along both sides of the Pecos River. The irrigation district lies in a basin cut off on the north by a canyon, through which the Pecos runs, and on

the south by canyons and rough country from below the Black River to the Texas line. This basin is undoubtedly the site of an ancient lake bounded on the west by the foothills of the Guadalupe Mountains, on the east by the scarp of the Staked Plains. The entrance to and exit from this basin were through narrow gorges cut in the hard carboniferous rock of the foothills. The sediments form the present soils of the district, modified to a great degree by the Pecos and the drifting action of the wind. The elevation of the country, or more likely the cutting away of the dam below Black River, placed the Pecos in position to commence the removal of the lake sediments. The river has begun the cutting and has already worn down to its hard rock over part of the district, and has commenced meandering in its bed, forming broad and treacherous sand bars. At other points in its course the Pecos has worn down to the conglomerate which lies at the base of the lake sediments.

The water supply of the Carlsbad area is derived entirely from the Pecos River. The original plans for irrigation contemplated taking the water direct from the river with a storage reservoir 6 miles above Carlsbad, with a capacity of 7,000 acre-feet. The situation of the dam is in a canyon with limestone walls, offering a natural abutment for the ends of the dam. This storage reservoir proving inadequate, a second reservoir was constructed 17 miles above Carlsbad, near Seven Rivers. This dam forms a lake 8 miles long and of an average width of 1¾ miles, with a storage capacity of 140,000 acre-feet.

SOILS.

Map 4 accompanying this report shows the soils of the Carlsbad area. Four distinct types of agricultural soil have been recognized and named, each type being different in its relation to irrigation waters and alkali and to vegetation. These types are as follows:

1. Pecos sands.
2. Pecos sandy loams.
3. Pecos conglomerate soil.
4. Gypsum loam or "yeso."

THE PECOS SANDS.

Along the Pecos River, filling up the tortuous bends of its course, are areas of sands blown about by the winds. The characteristic vegetation of mesquite, yucca, and canaigre in a great measure prevent the drifting of these sand dunes. The mesquite forms small dunes around its roots, and as the dunes build up the mesquite extends its roots, keeping on top of the dunes. In this way dunes 8 to 10 feet high are formed with mesquite growing on the top. This dune sand is composed of rounded grains of quartz with smaller quantities of gypsum and limestone. The texture of the dune sand is shown in the following table:

SAND DUNES WITH CHARACTERISTIC VEGETATION OF MESQUITE AND CANAIGRE, NEAR CARLSBAD, N. MEX.

When leveled down and put under irrigation make good truck land.

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Mechanical analysis of dune sand.

Diameter.	Conventional names.	4064. Carlsbad, 2 miles NW., 0 to 6 inches.
Millimeter.		*Per cent.*
2 to 1	Gravel	0.00
1 to 0.5	Coarse sand	.00
0.5 to .25	Medium sand	.22
.25 to .1	Fine sand	70.25
.1 to .05	Very fine sand	21.50
.05 to .01	Silt	2.70
.01 to .005	Fine silt	.43
.005 to .0001	Clay	4.22
Loss at 110° C		.42
Loss on ignition		.35

This type of sandy soil is from its texture well adapted to truck farming and root crops. Melons, potatoes, and small fruit grow well on this soil. It forms the soil of La Huerta, that part of Carlsbad north of the Pecos River and immediately adjoining the town. There are narrow strips of this soil found along the river as far south as the area was examined. Such a soil is not apt to be rich in plant food, but in the forcing of fruit and early vegetables this is not so necessary as ease of cultivation.

The virgin Pecos sand contains very little alkali. Examinations were made at points all over the area of the portion mapped out, and in no case was natural accumulation of alkali found. The alkali profile, in Figure 2*a*, shows the per cent of alkali in two typical soils, one never irrigated and the other irrigated. It will be seen that the irrigated soil on the average carries a little more alkali than the virgin soil.

THE PECOS SANDY LOAM.

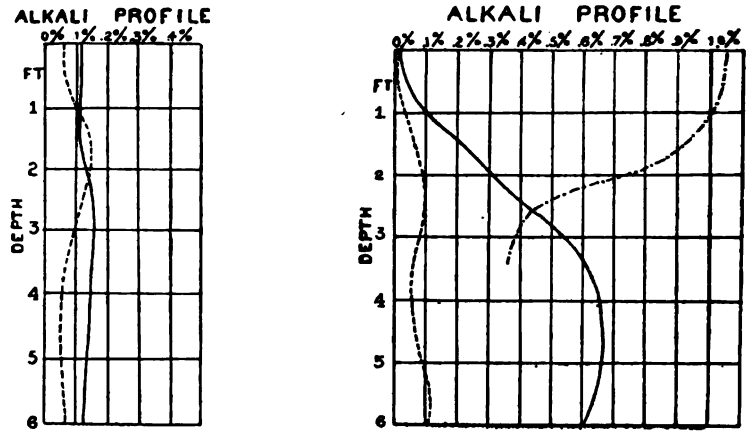
This is the most important type of soil in the Carlsbad area and covers the greater part of the irrigable land under the Southern Canal. This loam is very similar in character and texture to the Pecos sandy loam at Roswell.

The accompanying table shows the average texture of the soil.

Mechanical analyses of Pecos sandy loam soils.

Diameter.	Conventional names.	4067. ½ mile S. Otis, N. Mex., 0 to 12 inches.	4068. 1½ miles S. Otis, N. Mex., 0 to 12 inches.
Millimeters.		*Per cent.*	*Per cent.*
2 to 1	Gravel	0.00	0.00
1 to 0.5	Coarse sand	Trace.	Trace.
0.5 to .25	Medium sand	1.32	1.65
.25 to .1	Fine sand	10.20	12
.1 to .05	Very fine sand	36.30	41.45
.05 to .01	Silt	19.10	10.27
.01 to .050	Fine silt	3	10.45
.005 to .0001	Clay	18.65	18.72
Salts dissolved in 1½ liters of water, used in mechanical analyses		4	2
Loss at 110° C		2.60	2.67
Loss on ignition		4.70	2.45

The mechanical analyses of 4067 and 4068 represent typical soil from the Pecos sandy loam. These soils in the field appear much lighter in texture than the mechanical analysis would indicate. A microscopical examination of the soils was made to see the cause of this. Under the microscope a great many particles were found to consist of little conglomerates of clay cemented by lime. These particles upon shaking in the mechanical analysis gradually disintegrated, forming a soil which contained 32 per cent of clay. Since a mechanical analysis made in



a. In Pecos sand.
.... Before irrigation.
—— After irrigation.

b. In Pecos sandy loam.
—— Original soil.
..... Irrigated soil.
—·—·— subirrigated soil.

FIG. 2.—Diagram showing salt content to depth of 6 feet.

this way did not represent true field conditions analyses were made with only enough shaking with water to wash off the loose clayey particles. Also in soils containing gypsum and lime, the water used for the mechanical analysis dissolved a quantity of the gypsum and lime. This amount is indicated in the table as soluble in water, but must not be taken to represent the per cent of alkali salts.

In the field the breaking down of the particles is observed in spots continuously wet, and even with a normal amount of moisture the soils have become a little heavier by this disintegration. In some parts of the area this disintegration of the soil has gone on since irrigation commenced, and now we have irrigated soils which are heavier than non-irrigated soils situated under the same conditions.

The alkali profile given in figure 2*b* shows the per cent of alkali salt in the soil under three conditions: (1) The virgin soil; (2) the soil after irrigation, where drainage is good; and (3) the soil where irrigated when the drainage is poor or when subirrigated. The texture profile on the soil map shows the soil to be composed of nearly all (93 per cent) sand to a depth of 6 feet. Situated as these sands are, along the banks of the river, the drainage is normally good and the salt, which originally is found in the subsoil, is readily leached out and

rried away. Where this drainage is defective the evaporation from
e surface is sufficient to rapidly concentrate the soil solutions and
e alkali salts accumulate at the surface. Such a state of affairs is
nd along the foot of the gravel bluffs, in secs. 8, 9, 10, 14, and 15, of
22 S., R. 27 E. (See map 5.) Here the water in seeping out from
e conglomerate bluffs has swamped an area of land and the rapid
aporation of the water is swiftly producing an alkali flat.

The Pecos sandy loam contains about 20 per cent of carbonate of
ie. So much lime is objectionable to a great many plants, but fortu-
tely the class of plants grown in the Pecos Valley are tolerant of
ie. The humus content of the soil is low, as is true of many of the
d climate soils. Since the humus is the principal element of nitro-
n, this element is perhaps the element most needed in the Pecos
lley soils.

The plowing under of alfalfa is found to be of great benefit to sugar
ets, due to the addition of the nitrogenous organic matter of the
alfa. The practice of plowing under alfalfa has not been general,
ice the cost of seeding and starting alfalfa is heavy. The first year's
op is not sufficient to pay for the cost of planting. There are other
guminous crops which, without doubt, could be grown in the valley,
d could be turned under with profit.

The question of fertilizing, either with green manures or chemical fer-
izers, is one which farmers of the West are very loath to consider.
estern soils are usually rich soils, but in some districts even the
rgin soils are poor. Particularly is this true of soils in the true arid
gions, where the native vegetation is scanty and the humus content
the soils very low. The yield of sugar beets per acre upon the Pecos
am averages less than 5 tons per acre. This low yield is due partly
lack of proper plant food within the soil. No experiments, so far as
nown, have been conducted on the effect of fertilizers other than
alfa upon the growth of beets or other crops. This defect in the soil
realized by the farmers at present, and improvement in their methods
handling the soils is looked for in the near future.

PECOS CONGLOMERATE SOIL.

Underlying the Pecos sandy loam throughout the area examined is
und a bed of gravel or conglomerate. This conglomerate is exposed
ver many points in the area, and whenever so exposed its disintegra-
ion gives rise to a gravelly soil. This loose material is usually 2 feet
eep, underlaid by gravel or conglomerate. The table following illus-
rates the texture of the soil. No. 4069 contained 19.3 and 4070 con-
ained 26.1 per cent of coarse gravel.

Mechanical analysis of Pecos conglomerate soil.

Diameter.	Conventional name.	4069.	4070.
Millimeters.			
2 to 1	Fine gravel	Trace.	Trace.
1 to 0.05	Coarse sand	1.20	1.11
0.05 to .25	Medium sand	1.80	1.97
.25 to .1	Fine sand	12.51	12.88
.1 to .05	Very fine sand	45.77	39.81
.05 to .01	Silt	12.91	17.06
.01 to .005	Fine silt	3.48	3.46
.005 to .0001	Clay	17.22	18.23
	Loss at 110° C	2.21	2.37
	Loss on ignition	2.99	4.06

Presenting as it does such a large percentage of gravel, this soil i difficult to cultivate. Water readily leaches through it, and its irrig tion would require larg heads of water to cove short distances. Very litt of this gravelly land ha been cultivated. The are is seen to be large, and a land becomes scarcer an more valuable there will n doubt be a demand for thi gravelly soil.

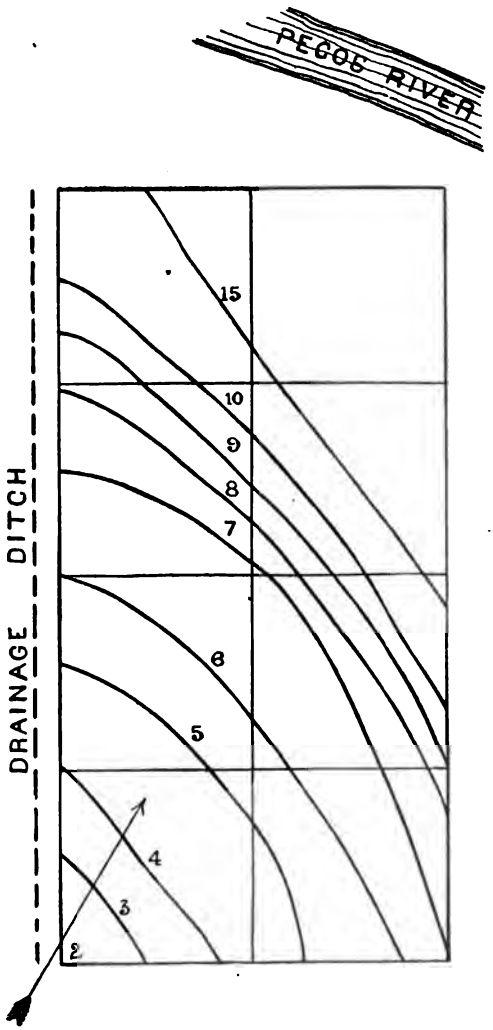


FIG. 3.—Diagram of orchard showing depth to standing water.

The ready penetration o the water in this soil make low-lying areas of it uncer tain, for water seeping up from below through the con glomerate soon swamps the overlying soil.

The canal over part of its course runs through the con glomerate. At these points quantities of water seep out of the bed and through the conglomerate to appear low er down. The alkali flats in several sections have been formed in this way from the seepage water out of the conglomerate bluff into the sandy soils along the river bottoms.

This permeability of the conglomerate offers one of the great sources of dan ger from seepage water. Though it offers a ready nat ural underdrainage for part of the upland, it is in the same way a great source of damage to the low-lying lands. Draws and flats adjacent to

CONGLOMERATE IN PECOS RIVER BED.

This layer of conglomerate extends under nearly all of the walls of the Carlsbad area, affording gravel for many miles and being an

e hills of conglomerate receive as seepage water the drainage from e upper lands.

Figure 3 shows the depth to standing water in an orchard near Carls- id being injured by seepage water and alkali coming from under the nglomerate. The arrow shows the direction of the underground ainage toward the Pecos River. The surface of the orchard is nearly rel and about 20 feet above the river. This shows the influence of e good drainage along the ver bank, in lowering the vel of the standing water.

Figure 4 shows the soluble lt content of the surface foot the orchard and the influ- ce of the good drainage ong the Pecos River. The lation of these lines to the ainage lines in figure 3 is ry apparent.

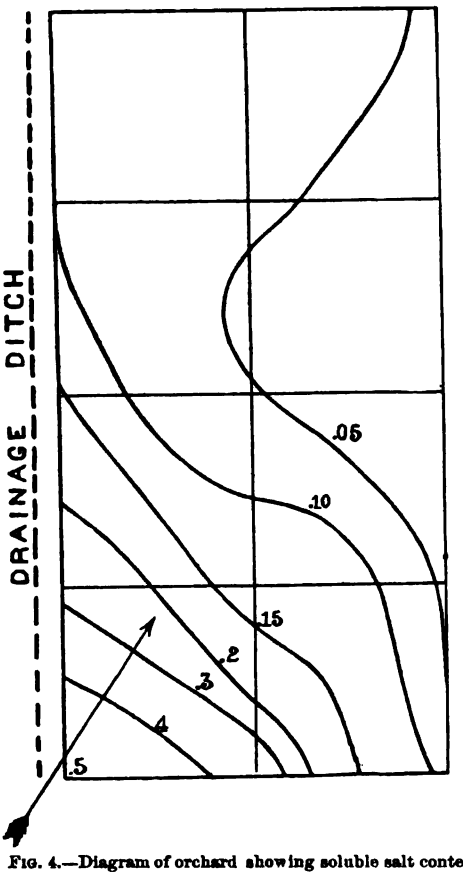


FIG. 4.—Diagram of orchard showing soluble salt content of surface foot.

GYPSUM LOAM OR "YESO."

The soil map shows a large regular-shaped area of gyp- um soil north of Black River nd another area south of lack River, around Malaga. This gypsum or "yeso," as ne native Mexicans term it, ossesses marked peculiari- es which merit a careful tudy.

The material is composed f nearly pure gypsum in a ranular form. When dry it s hard and compact, but pon wetting it absorbs water bout as readily as a lump of ugar and breaks down into a oft mass which is very per- ious to water.

Mechanical analyses of this naterial are very indefinite ecause the particles are so oft that they break up by agitation with water. The area mapped as gypsum soil does not everywhere have the gypsum on the immediate surface, but in nearly all places is covered with a thin layer of loam, derived from the decomposition of the gypsum or deposition by wind and water of other material. This loam varies in thickness from a fraction of an inch to 3 feet in depth.

The composition of the gypsum loam is shown in the accompanying table:

Mechanical analyses of gypsum loam soils.

Diameter.	Conventional names.	4071.	4074.
Millimeters.		*Per cent.*	*Per cent.*
2 to 1	Gravel		
1 to 0.5	Coarse sand	Trace.	
0.5 to .25	Medium sand	2.26	2.58
.25 to .1	Fine sand	9.42	14.25
.1 to .05	Very fine sand	38.47	37.13
.05 to .01	Silt	12.67	13.95
.01 to .005	Fine silt	10.87	8.88
.005 to .0001	Clay	19.70	15.46
Salts dissolved in 1½ liters of water used in mechanical analyses		1.90	2.34
Loss at 110° C.		3.03	2.80
Loss on ignition		3.41	3.27

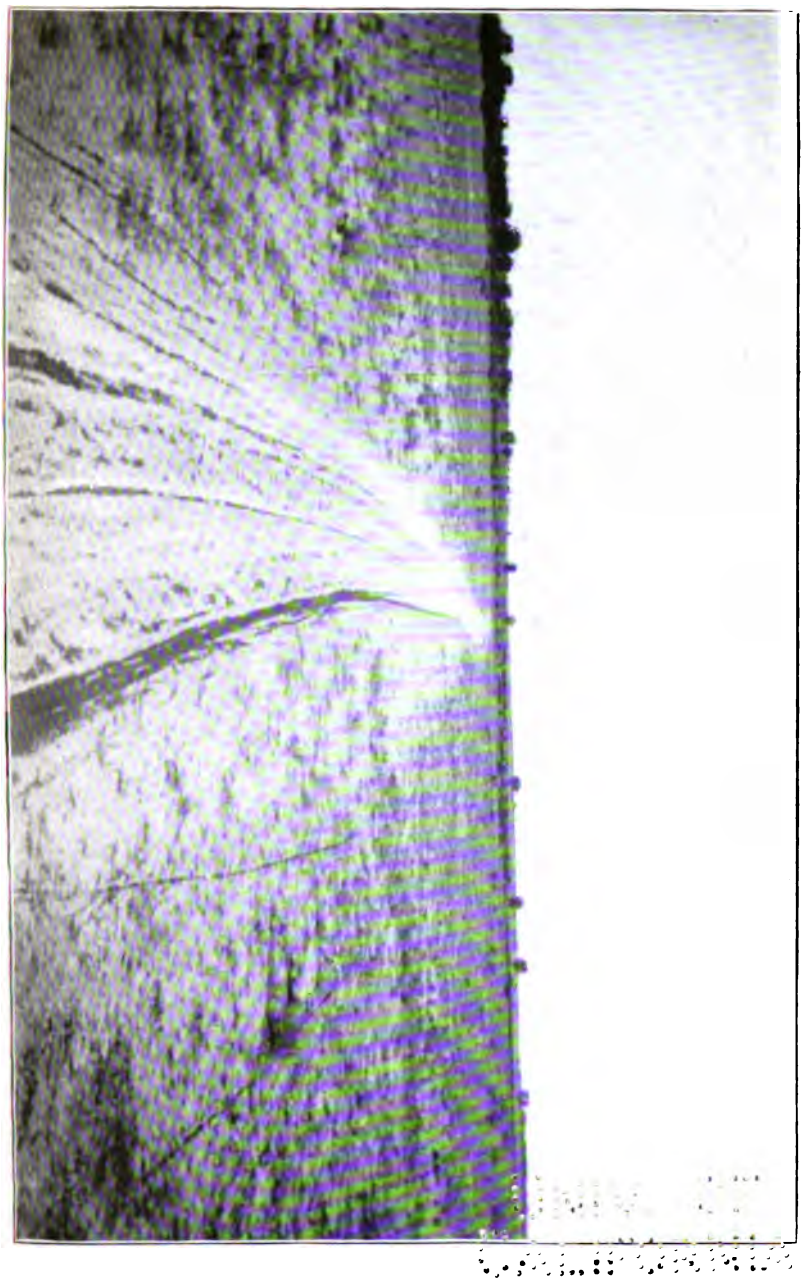
The most important physical property of the gypsum is its capillary power. When compared with another soil this property of the gypsum is remarkable. Wet spots have been observed in a field where on boring water could not be found within 6 feet of the surface.

A tube filled with the gypsum soil was placed with its lower end in water and the height to which the water rose was determined every day. The following table shows the results of the experiment:

Time.	Pecos gypsum, height in inches.	Pecos dune sand, height in inches.	Time.	Pecos gypsum, height in inches.	Pecos dune sand, height in inches.
15 minutes	1⅛	6⅛	6 days	37⅛	
45 minutes	2¼	11⅛	7 days	40	
1 hour	3	13	8 days	42¾	
2 hours	5	14	9 days	44¾	
6 hours	9⅛	17	10 days	46⅛	
24 hours	17⅛	18½	13 days	50½	
2 days	24	19⅛	14 days	52	
3 days	27⅛	20⅛	15 days	53	
4 days	32	20⅛	25 days	58	21

At the time the top of the tube was wet the water was slowly rising, and no doubt would have risen several inches higher. This great capillarity is of special importance and must be fully considered before reclamation by irrigation. The surface of the soil is kept moist all the time and the rapid evaporation from the surface causes the deposition of the alkali salts. It is undoubtedly this physical property which renders the cultivation of the gypsum soils so difficult in the Pecos Valley. The New Mexico Experiment Station has shown that, in itself, the gypsum is not harmful to plant growth, but in districts where water contains alkali salts the cultivation of the gypsum can not be recommended.

One of the most serious difficulties in the way of reclamation of gypsum lands would be their proper drainage. Canals, ditches, and laterals when passing through the gypsum are found to lose quantities of water by seepage, both lateral and downward. Cavities and underground channels are dissolved out in the gypsum, which makes it very



A GYPSUM SOIL WITHOUT THE USUAL COVERING OF LOAM, NEAR FLORENCE, N. MEX.

This material looks like white alkali, but is quite free from this except where affected by seepage water

ficult to drain the soil. Open drains have been seen in which the ter would flow in from one side, directly across the drain, and out o the subsoil on the other side. The great depth from which water raised by the gypsum would necessitate the placing of the drains per than usual. Open drains can not be used, for the gypsum erodes easily that the drains are not easily controlled. The irrigation lat-ls on the gypsum area, if run on a steep grade, cut deep trenches d fill up the subsoil with the water which seeps from their sides and ttoms. Plate VI shows such a lateral, which has cut a trench in places feet deep in the gypsum. The virgin gypsum carries small quan-ies of alkali salts in nearly all places examined, but at no point was accumulation of alkali salts encountered. A very different state of airs is seen after the gypsum has been irrigated. The top of the soil on becomes crusted over and the growth of agricultural plants pre-nted. Even where not cultivated, but in the vicinity of ditches and igated fields, the subirrigation of the gypsum is so great as in a few ars to destroy all vegetation which can not withstand quantities of kali.

From our present knowledge of the subject, the cultivation of pure psum soils is to be discouraged in the Pecos Valley.

The Water Supply of the Carlsbad District.

The irrigation water of the Carlsbad district is obtained by storage the Pecos water. It has been shown that the normal flow of the er is all from springs situated along its middle and lower courses in w Mexico. This water contains more or less alkali in solution all the time, and in standing in reservoirs the evaporation from the rface serves further to concentrate the water. The evaporation in ke McMillan has been found to be as much as 4½ inches per week, d, though authentic records are not at hand, the evaporation from a ter surface is estimated to be about 10 feet of water per year. This eat evaporation from the surface of a large reservoir is a very im-rtant item in the engineering of a storage system for the southwest. stimates by the engineer of the Southern Canal system at Carlsbad ring the summer of 1899 showed that during several weeks of May nd June the evaporation from the large reservoir exceeded the inflow om the Pecos by as much as 25 cubic feet per second. The inflow om the Pecos is at a minimum during the winter and early spring, nd the evaporation during this time continues to concentrate the ater, so that when the water is first needed for young, tender plants, ch as sugar beets, it is in its worst condition. The first floods, which ecur generally in May or June, bring down large quantities of salt hich have accumulated in the salt drains of the upper Pecos. These loods seldom improve the condition of the water. Later floods fur-ish the purest water of the season, and it is upon these floods of pure ater that the farmer should depend, if possible.

From analyses by Prof. E. M. Skeats, of Carlsbad, the condition of the water has been found to vary from 510 parts soluble matter in 100,000 parts of water found in the first floods, to 243 parts found in the later floods, with an average of 310 parts. Professor Skeats gives the following as the average composition of the soluble matter in the Pecos water:

	Parts per 100,000.
$NaCl$	98
$CaCO_3$	11
$CaSO_4$	130
$MgSO_4$	49
K_2SO_4	5
Silica, alumina, and iron	2
Water of crystallization, etc	15
Total salts	310

Of this it will be seen that 152 parts per 100,000 are salts likely to accumulate in the soil solutions and injure plants. The application of 2½ acre-feet of water would add 10,000 pounds of soluble salts to the soil, and, since 15,000 pounds can be taken as the maximum amount allowable in the surface foot of the soil, 1½ years only would be required so to fill the soil with alkali that agriculture would be unprof itable. This salt, however, is not all deposited in the surface foot, but is distributed in the soil as deep as the water penetrates, and if enough water is added to wet down to the level of standing water part of the salt left from the evaporation of the previous irrigation is washed away.

During June, 1899, a sample of the water from the main canal near Carlsbad was taken. A chemical analysis of this sample was made by Dr. Frank K. Cameron, chemist of this division, with the following result:

	Parts per 100,000.
$CaSO_4$	161.64
$MgSO_4$	2.16
Na_2SO_4	59.98
$NaCl$	168.16
	391.94
Undissolved after evaporation	43.28
Total salts	435.22

The water at the time this sample was taken was said to be so concentrated as to injure young sugar-beet plants. The osmotic pressure of a solution is the determining factor in its action toward plants; the water at this time contained about one-half as much salt in actual solution as could be endured by most plants. To this salt was added that already within the soil, so that the delicate rootlets were immersed

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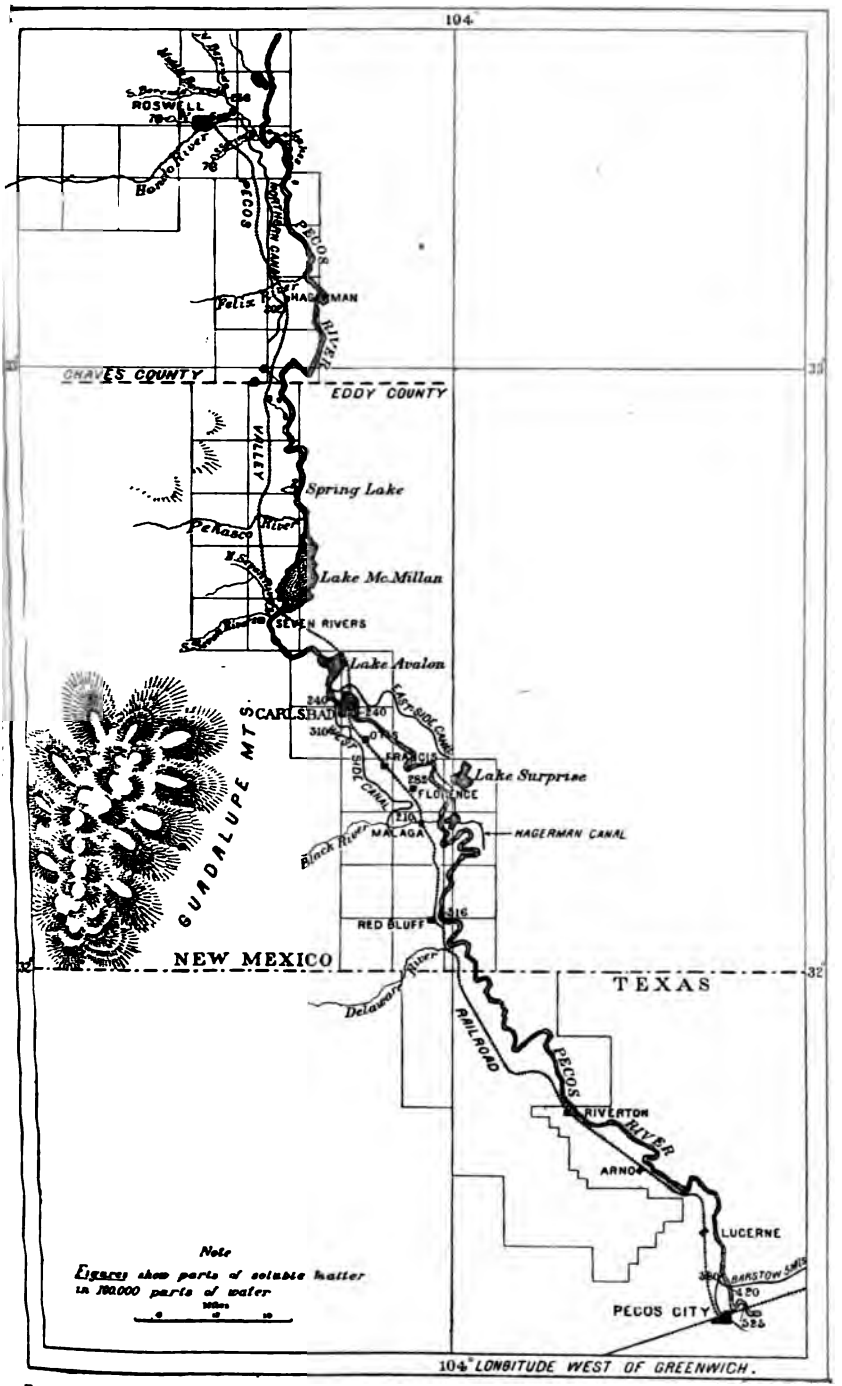


FIG. 5.—Sketch map of Pecos Valley, showing increase in salt content of water as it flows down the valley. (The figures show the salt content in parts per 100,000.)

in a solution almost as concentrated as they were able to stand. Under the intense heat of the sun of southern New Mexico this solution soon evaporates so much near the surface that it concentrates beyond the limit of plant growth. In the solution outside the rootlets the osmotic pressure becomes higher than the osmotic pressure inside the rootlets, and the plant dies of thirst though in the presence of plenty of moisture.

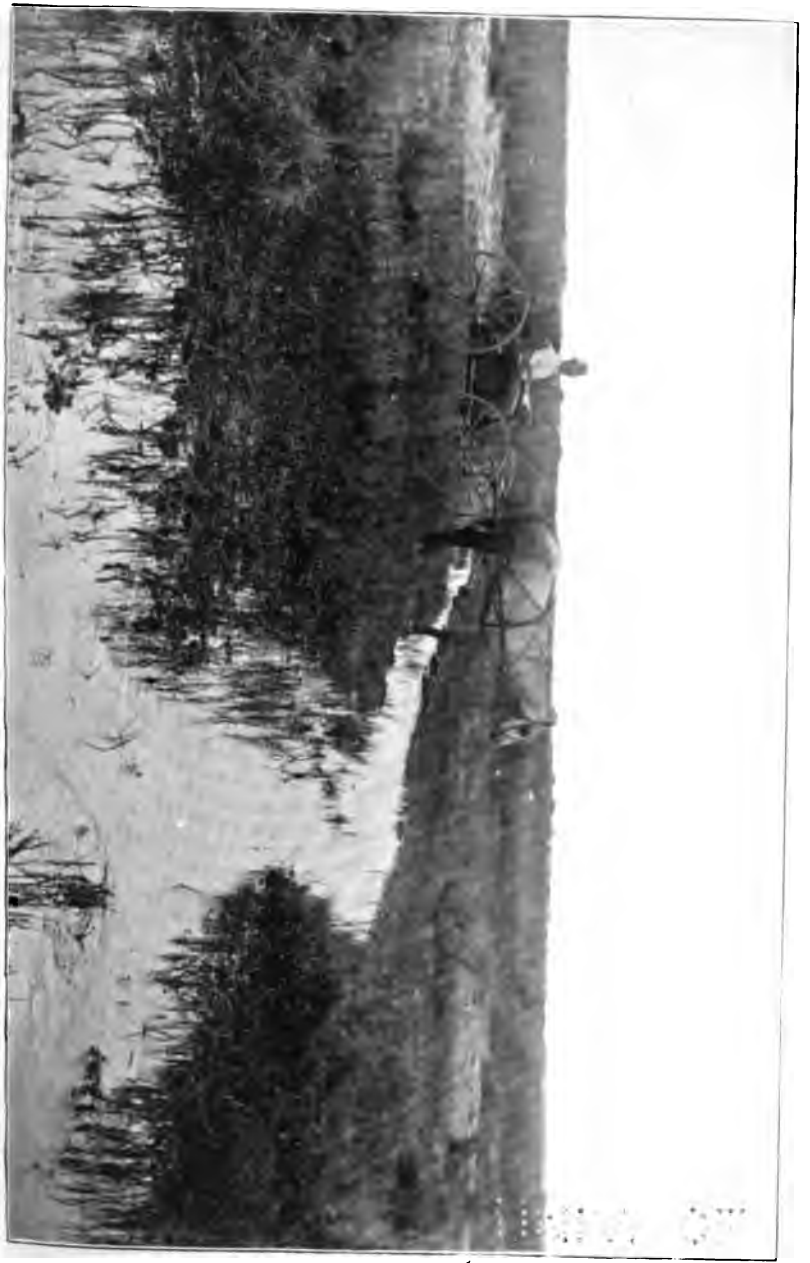
Figure 5 gives a graphic idea of the salt content of the water in different parts of the valley.

Underground Water.

One of the maps accompanying this report shows the depth to water, measured from the surface of the ground. The map indicates by the shades the three conditions of the land: (*a*) Water more than 10 feet below the surface; (*b*) water between 3 and 10 feet; (*c*) water 3 feet or less.

The general condition of the vegetation throughout the area watered by the Southern Canal system is not healthy. Crops are more subject to disease than is the case under similar conditions in humid climates. Sugar beets are subject to a root-rot; fruit trees suffer from something similar, and even alfalfa has a disease which attacks the roots. This unhealthy condition can be attributed to the condition of the irrigation water. Plants with their roots immersed in a solution of the concentration of the irrigating water from the Southern Canal are weakened and the germs of disease, which seem to be present in all of the soil, are enabled to attack the plant, weakening it further. This root disease is difficult to deal with, since the application of sprays to the roots is an impossibility. Some benefit has been claimed from the application of copperas around the roots of the trees.

The depth of wells over the greater part of the district was at least 40 feet originally; at present water can be found over nearly the whole of the irrigated land at less than 20 feet. In some of the wells which were dug 40 feet eight years ago water stands now at a depth of 5 to 10 feet during the irrigating season. In the winter, after the water has been taken out of the canals and laterals, the water slowly lowers in the wells. As soon as the water is turned in the main canal the level in the wells begins to rise, even before the irrigation commences on the lands around the wells. That the loss from canals and laterals is the greatest source of seepage water in irrigation districts is a fact which is coming to be generally recognized. There is without doubt much seepage water from overirrigated land, but the loss from constantly running canals and laterals far exceeds this. The loss from the canals of the Carlsbad district, while not great when compared with the loss of canals of other districts, is great enough to cause serious damage. The canal in crossing the beds of gravel and conglomerate loses appreciably by seepage. The following measurements of loss in



SEEPAGE STREAM FROM THE GYPSUM AREA, FLOWING ABOUT 2 CUBIC FEET PER SECOND.

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CALIFORNIA

nglomerate will illustrate this point. In running through the conomerate directly west of Carlsbad the canal loses 4 cubic feet of water r second in a distance of 1 mile. While this loss is not great when mpared with some Colorado canals, as reported by Carpenter, yet the ect of this alkaline water has been seriously felt in the flat to the st of the town, immediately along the foot of the gravel hill. The derground-water map shows an area in which water approaches to thin 3 feet of the surface. The greater part of this water is the epage from the canal, while part is due to the laterals in the town. ie water has accumulated to such a degree and has become concenated to such an extent by evaporation that the park trees and cottonods have suffered and many of them have died. A deep drain around e town would largely prevent this damage. Along the foot of the avel bluffs, in secs. 8, 9, 10, 14, and 15, T. 22, R. 27 E., is another ea in which water has seeped out from the gravel bluff, swamping the nd. This water flows under the higher lands immediately south, and) doubt has its origin in the canal. Some of the seepage water comes om the irrigation on this upland, but this source seems inconsiderable hen compared with the loss from the canal.

A third area of wet land on sec. 25, T. 22 S., R. 27 E. can also be tributed to seepage from the conglomerate. On the edge of this flat ater originally stood 40 feet below the surface; while at present, durg part of the irrigation season, it is unsafe to attempt to drive a horse long the roads through the flat.

The other areas, shown with water near the surface, are either in ie area of gypsum soil or are immediately adjacent to the gypsum. he loss in canals and laterals in the gypsum is great. The measureients in the following table illustrate such loss:

. *Measurements of loss in canals and laterals by seepage in gypsum.*

Lateral from gate 32 loses 1.64 cubic feet per second in 1¼ miles.
Lateral along south side sec. 12 loses 1.71 cubic feet per second in 1 mile.
Lateral from head gate 18 loses 0.89 cubic feet per second in ½ mile.
Main canal between gates 26 and 27 loses 2.62 cubic feet per second in 1½ miles.

All around the canal for a short distance below it the water stands iear the surface, coming by direct seepage from the main canal. Along ections 31, 32, and 33 the canal loses 2.6 cubic feet of water in 1½ miles. This water has seeped out, forming ponds below the canal. A number of photographs illustrating the condition of the country and showing the ponds formed from seepage were secured.

One of the photographs shows a stream flowing approximately 2 cubic feet per second, which seeps from the canal. Attempts have been made to stop the seepage from this piece of canal, but so far without success. The canal company contemplates abandoning this piece of canal and running the water directly into Black River, from which it will be taken by a canal to supply the lands south of Black River.

Alkali in Soils.

The alkali map accompanying this report shows three conditions of the soil: (*a*) Soil with less than 0.25 per cent of salt; (*b*) soil with from 0.25 to 0.50 per cent of salt; and (*c*) soil with more than 0.50 per cent of salt. The first represents land which is good; the second, land which contains sufficient alkali to damage crops, but not enough to prevent plant growth; and the third, land which already contains too much salt for crops. The alkali salts are entirely of the white kind—that is, containing no sodium carbonate. The following analyses, by Dr. Frank K. Cameron, were made on samples of crust collected by the members of the Division:

Number.	Locality.	$CaSO_4$.	$MgSO_4$.	Na_2SO_4.	$CaCl_2$.	$MgCl_2$.	NaCl.
4045	Six-mile dam	20.56	13.56	31	.....	.....	36.51
4046	Carlsbad, Pecos bank	3.62	39.92	35.73	.....	.....	20.87
4047	Carlsbad, Pecos bank	3.20	37.19	34.35	.....	.....	26.12
4048	West side Pecos, one-half mile south of Six-mile dam	11.29	25.76	5.67	.....	.....	56.61
4052	Carlsbad, one-half mile above	5.01	53.13	26.02	.....	.....	9.14
4054	Pecos bank, sec. 10, T. 22 S	11.68	54.94	4.60	.....	.....	28.75
4055	Southwest corner orchard, sec. 10, T. 22 S.	12.28	21.48	27.47	.....	.....	38.01
4056	Orchard, sec. 14, T. 22 S	7.06	24.52	32.47	.....	.....	36.14
	Alkali flat, sec. 14, T. 22 S	16.53	48.31	.....	.....	7.16	28.29
4053	Pecos bank, 100 yards above	23.45	29.14	28.26	.....	.....	19.14
4057	Mouth of Casa draw	6.33	18.50	33.06	.....	.....	42.11
4058	Sec. 14, T. 22 S	13.39	.....	.....	40.58	18.20	27.83
4061	Sec. 12, T. 23 S	46.44	7.52	26.46	.....	.....	19.57
4063	Delaware River bank	27.42	20.75	26.95	.....	.....	24.87

The soils were shown to contain originally only small quantities of alkali salts in their natural state, but at present there are areas containing great quantities of such salts. The presence of this alkali may, in nearly all cases, be attributed mainly to the salt which is contained in the irrigation water. The chemical composition compares nearly with the chemical composition of the salts contained in the waters. A comparison of the two maps, alkali map and underground water map, shows the relation between the seepage water and accumulations of alkali salts. In the area of gypsum soil the water is frequently below 6 feet, yet the capillarity is sufficient to bring the salt-laden water to the surface for evaporation.

Problems of the Area.

This area of land, on which immense amounts of work and money have been spent in reclamation, presents a number of problems for serious consideration. There are two important problems which are in a measure peculiar to the Carlsbad district. These are the methods of irrigating with an alkali water and the cultivation of gypsum land. The character of the water is the most serious difficulty in the way of profitable irrigation. To develop a new supply of water would be an engineering problem difficult of solution. The use of the present supply is attended with possible loss of crops, especially where the most favorable conditions do not exist. The greater part of the area of Pecos sandy loam has good drainage at present, and the difficulties

ALKALI FLAT CAUSED BY SEEPAGE AND SUBIRRIGATION OF THE GYPSUM LAND.

Ditches for carrying the moisture laden water off these alkali flats are furnished

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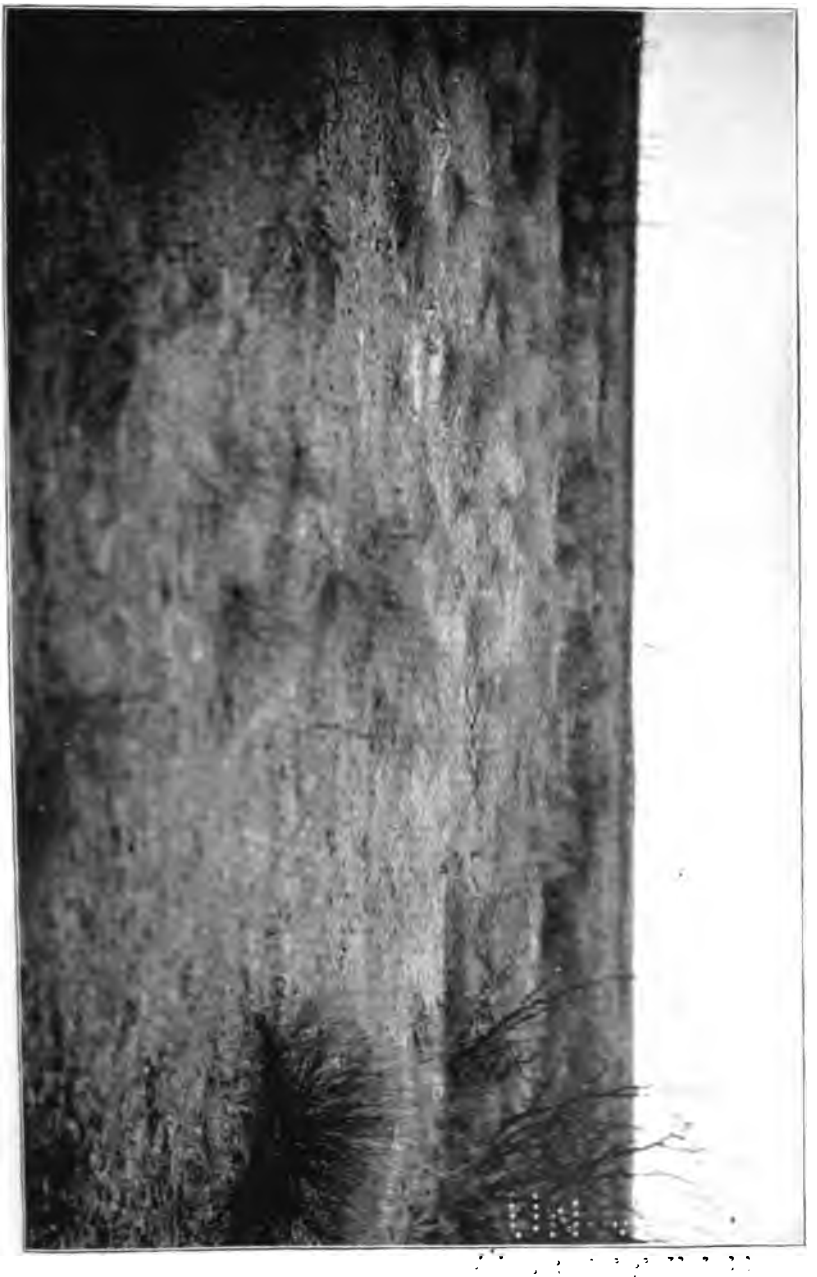

ALKALI FLAT FORMED BY SEEPAGE FROM CONGLOMERATE.

ncountered in these soils are at a minimum. Wherever the level of tanding water is below 10 feet, there is no present need of drainage; ut where (during its yearly fluctuations) the level of standing water pproaches the surface of the ground as close as 3 feet, drainage must e installed. Moreover, the accumulation of alkali from the summer's rigation should be removed by flooding and drainage during the late mmer and autumn when the irrigation water is at its best.

BARSTOW AREA, TEXAS.

A brief examination was made of the conditions at Barstow, Texas. ere the water is taken out of the Pecos River by a diverting dam ithout storage. The water at this point contains more salt than the ecos water at Carlsbad. Receiving, as it does, the drainage and epage waters from the Carlsbad irrigated lands and being augmented y alkali springs along its banks, the water at Red Bluff, below the wer limit of irrigation in the Carlsbad district, carried in May, 1899, 20 parts of soluble matter per 100,000. The waters of the Pecos at he Barstow intake carried in June 390 parts of soluble matter per 00,000, and opposite Pecos City, below all irrigation, it carried 525 arts per 100,000.

The application of water of this character to the soil, if long continued, is sure to result in an accumulation of salts beyond the endurance of agricultural plants, unless good natural drainage is present or rovision made for the escape of the salts by means of underground rains.

The soils are derived from the ancient lake basin sediments and are eavier in texture than the soils of the upper Pecos Valley. They riginally contained greater quantities of alkali salts and, in fact, there re evidences of the accumulation of salts in beds at depths below the urface. The soil of much of this area is underlaid by gypsum. This n its turn introduces new complications which render irrigation farming in this district extremely difficult.

The most favorable conditions only can be relied upon to give rofitable results in the irrigation of this district. The land has been nder cultivation for about five years and, owing to excessive leakage rom canals, seepage waters have accumulated to such an extent that nuch of the land has already been abandoned. All of the lands on the Pecos City side have been abandoned, and at present irrigation is confined to the Barstow or eastern side of the river.

The most promising field for such a district would be the cultivation of saltbushes and other plants resistant of alkali. Water from the Pecos, when the water is in its best condition, should be flooded over the land to wash away accumulated salts near the surface. This salt would have to be removed by good underdrainage, if intensive farming is contemplated.

A district lower down on the Pecos is reported to be entirely abandoned from the excess of alkali which the water and soil contained.

SUMMARY.

The foregoing pages have shown that the condition of the water in the Pecos River becomes more saline as one descends the river. This fact is well brought out in the sketch map of the Pecos Valley, fig. 5. On this map the parts of salt per 100,000 parts of water are shown by figures. The seriousness of the alkali problem varies in direct ratio to the salt content of the water. At Roswell the alkali is within the soil; the irrigation water is good. By washing the alkali from the soil with the pure water the alkali may be removed and the land thoroughly reclaimed. If once the alkali is removed by the soils being drained, there need be no further fear of damage from alkali. The water of the Berendos contains alkali in sufficient quantity to be harmful to lands, unless well drained. The use of this water has been almost entirely restricted to lands lying close to the deep-cut river channels, where natural drainage is good; therefore the damage from this water has been slight. The water of the Northern Canal contains 0.2 per cent of alkali, and care should be exercised in using it. The soils at Hagerman contain at present alkali, most of which has been derived from the evaporation of the Northern Canal water.

The water of the Carlsbad system contains on an average 0.31 per cent of alkali salts. The soils originally contained very little alkali, the greater part of that now present being due in all probability to the concentration of the irrigation water. The salt already accumulated must be removed by drainage, and all further accumulation must be prevented by washing out with fresh water during the winter or when the water is plentiful and fresh.

The soils of the Pecos Valley are deficient in organic matter and nitrogenous plant food. The growth and plowing under of leguminous crops is recommended, together with fertilizing with stable manure when such is attainable. In the southern part of the valley, where sugar beets form a money crop for the farmer, chemical fertilizers would be of value. Economy in the use of water and the prevention of leakage from canals or laterals will overcome much of the seepage, which at present is the principal cause of the alkali.

The authors wish to acknowledge their indebtedness to Mr. W. Hamilton, manager of the Roswell Land and Water Company, for base maps and for material assistance in the prosecution of the investigation in the Roswell district; also to Mr. Charles A. Bremond, Mr. Luigi Martini, and others for help and interest shown in the work.

At Carlsbad credit is due to Messrs. Tansil, F. A. Tracy, and W. M. Reed, officers of the Southern Canal system, for maps and assistance, and to Prof. E. M. Skeats for valuable data, including chemical analyses relating to the district; also to A. E. Goetz and others.

During the short time spent at Barstow, Tex., Mr. G. E. Briggs, manager of the Pioneer Canal Company, assisted personally in the reconnoissance of that district.

A SOIL SURVEY IN SALT LAKE VALLEY, UTAH.

By FRANK D. GARDNER and JOHN STEWART.

PHYSIOGRAPHY.

Beginning in July, 1899, four months were spent in a thorough and detailed study of that portion of the Salt Lake Valley lying west of the Jordan River, the object being to map the soils with reference to their character and to the extent of, and damage from, "alkali" and seepage waters. The soils were classified according to their texture, and the waters examined with reference to their quality for irrigation purposes. The soils were further studied with reference to their "alkali" content and its effect in varying amounts upon the crops and vegetation. The methods of irrigation were looked into with regard to their success or failure and the ultimate outcome in relation to the condition of the soils, especially with reference to the accumulation of alkali and seepage waters.

Nearly 700 borings were made in this district, usually to a depth of 6 feet and occasionally to 9, 12, or 15 feet. In two-thirds of these borings the per cent of salt at saturation in each foot section was determined by the electrical method, and in a considerable number of the borings the sodium carbonate (true black alkali) was determined volumetrically. In areas where hardpan forms an important feature, it was mapped and its depth and thickness ascertained. A study was made of its influence toward the action of roots and water together with the probable mode of formation.

Full notes were made on the character of the natural vegetation and the kinds and condition of the crops. Wells, both surface and artesian, were examined with reference to their water, the depth to standing water, and the nature of the strata through which they were dug. Drainage and seepage waters were tested with regard to the salts they were carrying from the soil.

Only such of the data collected as is essential for a clear understanding of the conditions is herein given, the results being embodied in the following text and accompanying maps.

Salt Lake Valley comprises about one-half of Salt Lake County, the remainder being occupied by the Wasatch Mountains to the east and

the Oquirrh Mountains to the west. The mountains close in on the south in what is known as the Jordan Narrows, thus practically surrounding the valley on three sides and leaving an opening on the north where it borders on the Great Salt Lake. It is one of many similar valleys which, lying between mountain ranges more or less parallel, go to make up the lower and more level parts of the Great Interior Basin, a broad area of varied surface naturally divided into a number of drainage districts.

The general form of the Great Interior Basin is triangular, with the acute angle to the south where it extends into old Mexico. At its greatest extremes it is 880 miles from north to south and 570 miles from east to west, including an area of 210,000 square miles. It comprises nearly the whole of Nevada, the western half of Utah, small portions of Idaho and Montana, and large areas in Oregon and in eastern and southern California.[1]

The region is characterized by many short and usually parallel mountain ranges, extending generally from north to south, between which are smooth valleys whose alluvial slopes or floors are built up of the débris brought down from the mountains. The character of the climate is plainly seen in the hydrography and vegetation. Perennial lakes occur only in association with the larger mountain masses, while the vegetation of the valley is usually sparse. The annual rainfall varies from 2 inches in the south to about 20 inches in the mountains in the north, while the annual evaporation from a free water surface varies from 60 inches in the north to 150 inches in the south. The larger mountains have timber in their recesses, but only conifers attain such size and abundance as to be of economic importance. The climate of the whole area may be classed as arid.

The largest subdivision of the Great Basin is the Bonneville Basin (fig. 6), containing 54,000 square miles, or a little more than one-fourth of the former. Slightly more than two-fifths of the Bonneville Basin was once occupied by the ancient Lake Bonneville, whose area was 19,750 square miles. This ancient lake apparently reached its greatest extent during the epoch of maximum glaciation, as is shown by the presence of a number of glacial morains which descend on the sides of the Wasatch Mountains to the well-marked shore line of the lake when at its highest stage. This shore line, known as the Bonneville shore line, forms a striking feature of the mountain side, both to the east and west, and is plainly visible from all points of the valley. (See Plate X.) The great upheavals which made the mountains and valleys of this region evidently occurred prior to the age of the lake, although there have been

[1] The following brief description of the characteristics and history of the Great Interior Basin and of Lake Bonneville is essential to an understanding of the present conditions. Some of the facts and figures relating to the basin and to the time and extent of the ancient lake have been taken from G. K. Gilbert's report on Lake Bonneville, published as a monograph by the United States Geological Survey in 1890.

minor changes in the elevation since then, as shown by faults at the western bases of the Wasatch, Oquirrh, and Aqui mountains and by the variations in the altitude of different parts of the Bonneville shore line. The altitude of this shore line has been ascertained in a number

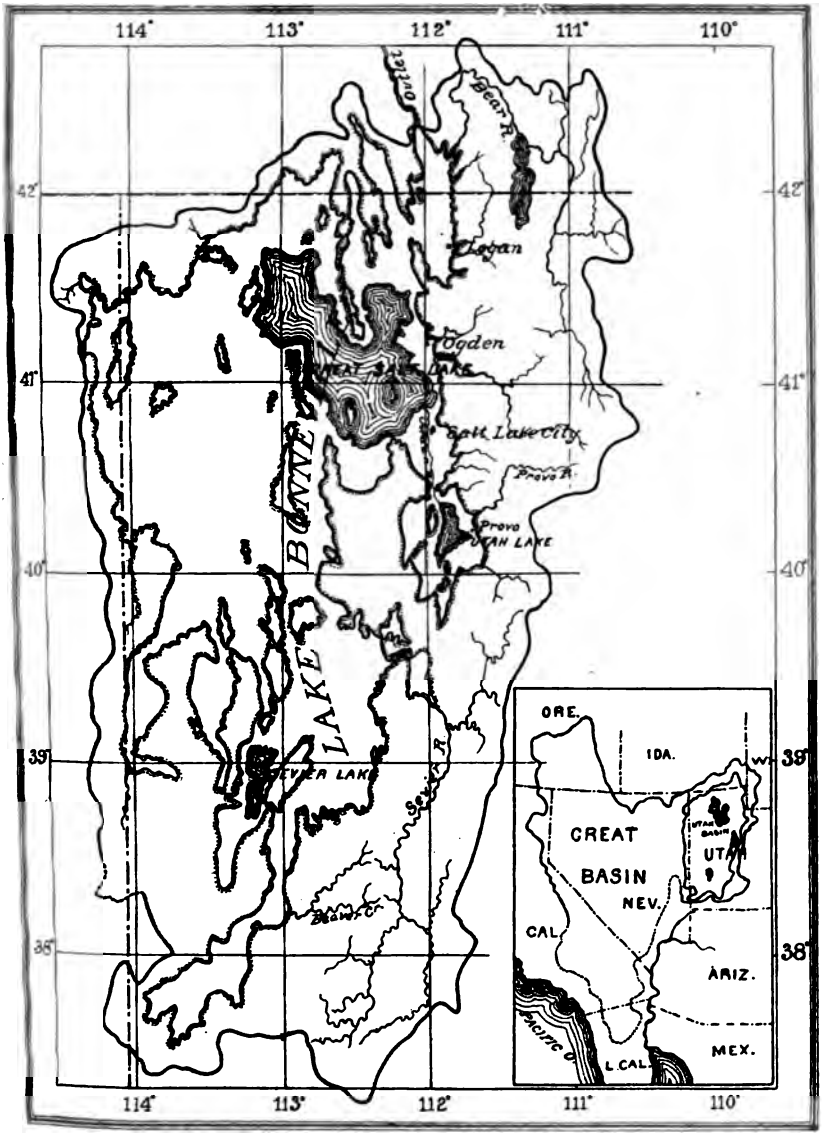

FIG. 6.—Sketch map of Bonneville Basin, showing ancient lake and present lakes.

of places, and, except in a few measurements at the extreme south, it varies from 900 to 1,070 feet above the present level of Great Salt Lake, with a mean elevation of about 1,000 feet. All evidences point to the fact that the surface of Lake Bonneville was at that time 1,000 feet

higher than the present surface of Great Salt Lake and that its area extent exceeded the present lake by 13.3 times. At its highest stag the lake overflowed the rim of the basin, the water escaping into Snak River. A deep channel was eroded, forming what is now known a Red Rock Pass. The level of the lake was thus lowered 375 feet, a which point erosion ceased and no further escape of water occurred i this manner. Here the water level was maintained for a considerabl period of time, as is shown by the formation of a well-marked beac line which is known as the Provo shore line. After this stage the lak water fell to its present level by evaporation, occasional interruption being now noticeable by the number of intermediate shore lines mor or less distinct. There is strong evidence of very great climatic chang from epochs of great precipitation of snow and rain to periods whe high temperature and excessive evaporation occurred. It is not at al improbable that the Great Salt Lake may have been dry at some period although this question has never been settled.

The modern Great Salt Lake is but a remnant of its ancient prede cessor, which at the time of its overflow may be considered as a fresh water lake. Since the Provo stage, however, the water escaped only by evaporation through a long period of time during which the evapo ration exceeded the precipitation, causing as a result a body of water containing in solution 22 per cent of salt. At the Provo stage the water surface of the ancient lake was 625 feet above the present level of the Great Salt Lake as determined by the altitude of the Provo shore line in a number of places. (See Plate X.) The mean depth of Great Salt Lake is now about 13 feet; therefore, the water over its present area at the Provo stage was forty-nine times its present depth. A comparison of its area at the two periods shows that at the Provo stage it was 7.4 times its present area. Assuming that the mean depth of the whole body of water at this early period was one half the mean depth of water at that time over the present lake, the volume of water at the former time is found to be one hundred and eighty-one times the present volume of Great Salt Lake. If it were further assumed that the lake at the Provo stage was fresh and contained, as the Utah Lake now does, about 80 parts of soluble matter in 100,000 parts of water, we would have, by evaporation to the present volume of Great Salt Lake, a solution containing 14.5 per cent of salt, providing none of the salt was precipitated during the process of evaporation. As a matter of fact the lake now carries about 22 per cent of salt, which leaves about 7½ per cent unaccounted for. We find, however, that the inflowing streams carry sufficient water to equal the volume of the lake water every 2½ years; and if it is assumed that they carry a percentage of salt equal to that carried by Utah Lake, it would require only two hundred and fifty years for them to carry the remaining 7½ per cent and bring the saltness of the lake to its present stage. No doubt considerable quantities of the less soluble salts—as, for example, carbonate of lime and sulphates of

Lower Boundary of Marker on Mountain 3 or 4 Miles East of Garfield Beach.

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lime and soda—were deposited, but the period of time since the Provo stage has undoubtedly been much longer than two hundred and fifty years. It seems, therefore, quite simple to account for the present high salt content of the Great Salt Lake. At a time when the lake was just high enough to cover the lower levels of the Salt Lake Valley, the water must have been sufficiently salty to have left the soil in a very salty condition upon the subsidence of the water. As a matter of fact, large amounts of salt are found in the lower levels, especially in the lower depths of the soil.

Within the memory of the present inhabitants the level of this lake has varied fully 12 feet. In 1850 it was very low, but for several years thereafter it rose slowly. It then began to fall again, reaching a very low stage from 1861 to 1864. From 1864 to 1868 there was a period of excessive rainfall, during which time the lake rose rapidly, reaching such a height in 1868 that fully 50 square miles of what was mapped

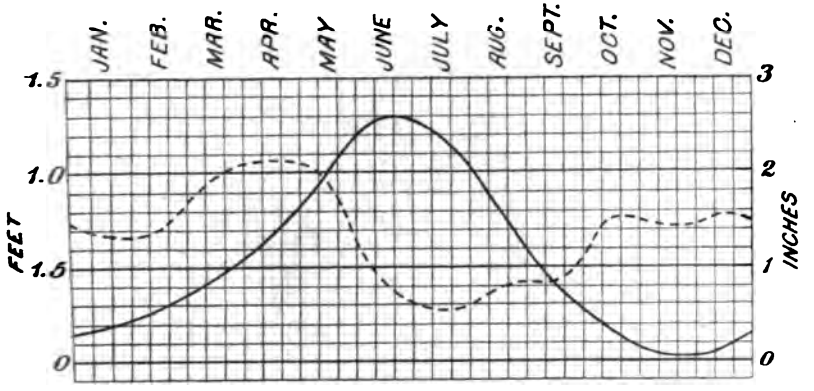

FIG. 7.—Diagram showing mean monthly fluctuations in water level of Great Salt Lake and the rainfall during same period. (The solid line represents level of lake; the broken line the rainfall.)

this season as dry land was submerged by its waters. Since that time there have been three distinct periods of rise and fall, but the general trend has been downward, until at the present time the level is about where it was in 1850. Besides this, there is an annual fluctuation, during which the lake reaches its maximum about June 1 and its minimum about December 1. This annual variation, amounting to from 1 to 2 feet, is the result of a low rainfall from June to September, inclusive, accompanied by high temperature and low relative humidity, conditions favoring rapid evaporation and of a greater rainfall and less evaporation during the remainder of the year. This is shown in figure 7.

The accompanying diagram (fig. 7) shows graphically the mean monthly rainfall in inches as compared with the monthly change in the level of the lake in feet. The maximum rise of the lake occurs about two months after the close of the rainy period, and it is about the same length of time after the rain again begins before the lake commences

to rise, which shows that the maximum effect of precipitation on the lake occurs about two months after the precipitation has taken place. Figure 8 shows the semiannual variation in the lake level for the past fifty years, with the accompanying annual rainfall. There is a general agreement between precipitation and the lake variation.

The surface of Great Salt Lake is 4,170 feet above the sea level, while an additional 50-foot contour line would include the lower and more level portions of the valley, amounting to one-half of it. Above this the land inclines toward the foothills at the rate of from 50 to 100 feet per mile. To the east the Wasatch Mountains rise abruptly, attaining a maximum height of 7,000 feet above the general level of the valley. Their snow-clad summits and numerous springs are the source of a number of perennial streams that flow across the eastern part of the valley and enter the Jordan River. These streams furnish an

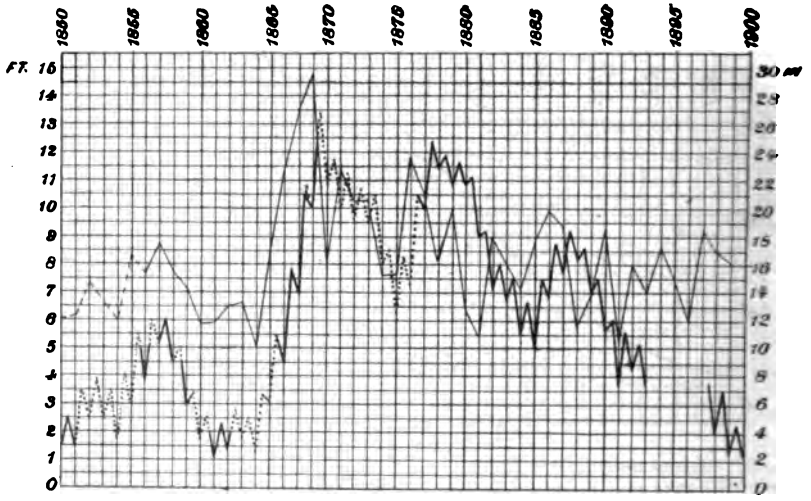

FIG. 8.—Diagram showing mean annual fluctuations in water level in Great Salt Lake and the rainfall during the same period. (The heavy line represents the level of the lake in reference to an established bench mark; the light line represents the rainfall in inches.)

abundant and good water supply for irrigating the eastern portion of the valley. To the west the Oquirrh Mountains rise less abruptly, reaching an elevation of from 4,000 to 5,000 feet above the valley. The watershed is not so extensive as to the east, and there is less snow, so that the few streams flowing from the canyons are lost, by evaporation or seepage, before they reach the Jordan River. The Jordan River is the main channel through which the waters of Utah Lake and its inflowing streams reach Salt Lake. It is on the Jordan River that the western portion of the valley is dependent for irrigation water.

The mountains consist chiefly of granite, limestone, sandstone, quartz, porphyry, and feldspar, and it is from these rocks that the soil of the valley is formed. The mountains abound in ores rich in silver, lead, and copper. Many mines are in operation and furnish material for several large smelters located in the valley.

The lake is also a source of commercial enterprise, and according to ne statistics of 1890 the value of the annual output of the salt harested from the evaporating ponds amounted to $250,000.

CLIMATE.

The climate of Salt Lake Valley is characterized by low annual precipitation, low relative humidity, moderate wind movement, moderate emperature, and abundant sunshine. It may be classed as arid. Acording to the United States Weather Bureau records for the past 25 ears, the mean annual precipitation at Salt Lake City is 16.2 inches, ith a minimum of 10.3 inches in 1890 and a maximum of 23.6 inches in 875. Previous records, shown in the chart on page 82, show a range annual precipitation of from 10 to 29 inches. Of the mean annual ainfall a total of only 2.9 inches falls during the months of June, July, August, and September. These four months of mean minimum precipitation are accompanied by mean maximum temperature and low relative humidity—conditions favoring excessive evaporation.

Since this is the period in which crops make most of their vegetative growth, it will be seen how important and necessary is irrigation water for farming. In fact very little farming is carried on except under irrigation. Statistics for 1894 show that 92.5 per cent of the farms in Salt Lake County are irrigated. Wheat is the only crop that is grown without irrigating and it makes most of its vegetative growth prior to June. The average yield of wheat under dry farming is slightly more than one-third of the average yield under irrigation.

The accompanying table shows the monthly and yearly precipitation at Salt Lake City for the past 25 years as obtained from the United States Weather Bureau office at that place.

Monthly and annual precipitation, Salt Lake City, Utah, from 1874 to 1899.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1874	.....	.....	a1.31	0.90	2.84	0.74	2.42	1.63	0.20	1.74	2.16	0.73	14.67
1875	3.05	0.79	2.81	1.50	2.91	.90	1.01	.25	1.22	1.36	5.81	2.03	23.64
1876	1.23	1.52	4	2.09	4.30	.09	.83	.92	.42	3.27	.81	1.80	21.28
1877	.87	.38	2.93	2.14	3.49	.80	.02	.28	.90	2.41	1.02	1.11	16.35
1878	1.07	3.49	2.54	2.63	2.50	.35	1.08	.81	3.15	1.39	.63	.11	19.75
1879	1.87	.71	.67	3.26	.10	1.34	.07	.06	.01	1.62	.32	3.08	13.11
1880	.29	1.02	.43	2.37	1.85	.01	.20	.74	.56	.40	1.17	1.90	10.94
1881	1.24	2.44	.88	2.37	2.55	.28	.21	1.66	.43	2.19	1.44	1.24	16.93
1882	1.50	.42	1.12	3.81	.26	2.24	.30	1.61	.37	2.89	.54	.92	15.98
1883	1.47	.72	1.75	2.92	.98	.33	.10	.62	.13	2.24	1.78	1.20	14.24
1884	.71	2.23	3.69	2.89	1.78	.33	.27	.73	1.91	.36	.50	2.12	17.52
1885	1.48	1.56	.64	b3.47	2.49	2.67	.58	.90	1.29	.59	3.10	.92	19.69
1886	1.91	1.36	2.60	4.43	.06	1.02	T.	.59	1.88	1.98	1.79	1.27	18.89
1887	2.36	1.41	.35	1.87	.73	.37	1.23	.69	.55	.30	.25	1.55	11.66
1888	1.52	1.22	2.18	.99	.34	.98	.24	.63	.51	.80	2	2.21	13.62
1889	.73	.81	1.64	1.52	2.97	.01	.08	.92	.52	3.85	1.04	4.37	18.46
1890	3.07	2.05	1.12	.94	.16	.32	.02	.79	T.	1.44	T.	.42	10.33
1891	.74	.76	4.66	1.49	.72	1.08	.47	.46	1.19	1.26	.90	2.19	15.92
1892	1.61	.68	2.21	1.90	1.65	1.21	T.	.05	.12	1.58	.72	2.35	14.08
1893	.82	1.64	2.68	2.72	1.68	.04	1.19	.71	1.30	1.02	1.18	2.37	17.35
1894	1.31	.83	1.73	1.67	1.22	1.38	.82	.87	2.87	1.01	.28	1.28	15.27
1895	1.32	.85	.81	.73	2.29	.99	.42	.02	.95	.24	2.44	.89	11.95
1896	1.26	.69	1.99	2.53	3.67	.25	1.35	1.47	.52	.70	3.15	.84	18.42
1897	1.16	3.81	2.20	2	.96	.52	.69	.33	.48	1.91	1.19	1.47	16.74
1898	.56	.38	1.71	1.30	4.19	1.45	.18	1.35	.15	1.57	1.95	1.28	16.09
1899	.84	2.98	2.93	.81	2.59	.96	.42	1.06	T.	.....	.....	.....	12.59
Sums	34.01	34.75	51.58	55.25	49.30	20.66	14.20	20.15	21.63	38.12	36.17	39.65	402.88
Averages	1.36	1.39	1.98	2.12	1.90	.79	.55	.78	.83	1.52	1.45	1.59	16.18

a 12 days. b 28 days.

The annual precipitation in the mountains is greater than in the va leys, and it is estimated that it includes 6 feet of snow, which lingers the mountains the greater part of the summer. This is important relation to irrigation, because it makes the water supply plenti throughout the season.

The annual evaporation from a free water surface in Salt Lake Valle is estimated at 8 feet. Data from one of the salt companies show th evaporation from their ponds to be about 37 inches from June to Se tember, inclusive. It should be borne in mind, however, that this from a saturated salt solution and that the presence of much salt lowe the vapor tension, and, consequently, the rate of evaporation. Th evaporation from a fresh-water service would no doubt have been mu greater.

The mean annual temperature is 51.2° F., with a mean maximum 75.6° in July and a minimum of 27.9° in January. The mean tempera ture for from June to September, inclusive, is 70.5° F.

The following table gives the mean monthly and yearly temperatur for the past twenty-five years.

Mean monthly and mean annual temperature, Salt Lake City, Utah, from 1874 to 1899.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	An- nual.
1874	.....	.....	.....	.....	.....	67.1	77.8	74.6	62	56.4	43.2	33.9	.....
1875	29.5	34.2	35	48.9	59	67.8	74	75	68.1	58.2	42	36.2	52.
1876	30.5	36.1	37.2	49.8	56.7	63.6	76.5	71.6	65.8	55.3	41	27	51.
1877	27.2	34.1	46.9	48.8	56.2	65.4	77.4	75.8	64.4	51.6	40.6	32.1	51.
1878	30.3	37.8	47.1	49.4	56.4	68.5	76.9	78.4	60.6	49	44	29.8	51.
1879	28.3	39.6	49.2	52.6	58.2	65.2	76.8	75.4	68.5	52	36	29.4	53
1880	28.2	26.2	34	46.8	54.2	66	74.2	72.8	63.6	52	29.6	34.6	48.
1881	30.8	38.2	42.2	54.2	60.2	71.2	76	74.4	60.2	50.8	33.8	33.6	51.
1882	23.5	26.9	36.6	46.7	57.2	67.3	75.4	76.9	64.8	48.4	35.5	35	48.
1883	24.4	24.1	47	45.6	56.7	70	76.2	76.8	69.7	46.3	29.2	32.5	50.
1884	28.4	30.7	40.8	48	57.9	69.1	74	72.7	59.4	53	42.2	35.2	51.
1885	27.6	36.8	45.6	53.5	56.6	64.8	76.1	73.7	65.1	54.9	43.8	33.9	52.
1886	28.8	40.8	37.7	48.4	62.4	68.9	78.1	76.1	62.8	51.8	31.4	36.1	52.
1887	33.2	34.1	47.2	49.2	60.8	68.6	74.9	73.4	65.5	51.6	42.8	29.2	52.
1888	22.9	38.3	40	54.8	58.6	68.4	76.6	74.8	70.6	54	41.6	35.8	53
1889	21.4	29.8	47.7	55.2	58.8	70.3	78.4	77.4	60.6	54.2	39	32.6	53.
1890	24.8	33.7	39.5	50.4	61.3	64.8	77.8	72.9	65	48.6	41	26.2	51.
1891	28.8	30.6	38	49.6	60	62	73.3	74.4	65	53.2	44.2	28.6	50.
1892	25.8	33.6	43.4	47.4	55.4	65.8	76	75.4	69.6	51.8	42.2	27.6	51.
1893	27.6	28.5	39.3	45.9	55.1	67	74.7	73.3	63	52	39.4	36.3	50.
1894	29	25.6	41.1	48.1	61.2	63.9	74.6	75.4	61	53.2	45.6	31.4	50.
1895	29.7	30	40.8	51.2	57.9	63.5	72.6	74.8	63.8	54.3	37.8	36.4	50.
1896	34	36.8	40.2	46.4	51.4	70	74.2	73.7	64	54.4	37.2	36.2	51.
1897	28.8	30.9	33.6	49	63.4	66	71.9	75.2	62.2	50.9	43.2	27.4	50.
1898	20.6	35.6	36.3	54	53.9	67.1	75.9	76.8	65.6	48.2	37.3	25.2	49.
1899	33.8	29.6	40.6	50.6	52.6	65.1	76.2	69.8	67.1	.....	.....	.....	.....
Average	27.9	32.9	41.1	49.8	57.7	67	75.6	74.7	64.5	52.2	39.7	32.4	51.

The mean annual wind movement is at the rate of 5.4 miles per hour, with a maximum of 6.4 miles in May and a minimum of 4.3 miles in November.

The following table gives the monthly and annual wind movement Salt Lake City for the past twenty-five years. As a whole, the nate is both pleasant and healthful.

thly and annual wind movement in miles at Salt Lake City, Utah, from 1874 to 1899.

ar.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
....	.....	.....	.....	4,227	4,116	4,231	3,421	3,924	3,240	2,681	3,076	2,272	*a* 31,188
....	3,395	2,701	4,492	4,394	4,672	4,407	3,923	4,406	3,983	3,087	3,262	2,031	44,753
....	2,915	2,460	4,169	3,689	3,537	3,570	4,252	4,910	4,524	3,418	2,887	1,636	41,967
....	3,222	2,411	4,219	5,206	6,291	4,531	5,165	4,848	4,783	3,998	3,777	2,978	51,429
....	2,569	3,568	4,150	5,057	5,229	4,970	5,535	4,083	3,830	4,406	3,148	2,895	49,440
....	2,898	3,336	5,001	4,739	6,410	5,085	4,503	4,783	4,104	3,694	2,222	3,605	50,380
....	3,516	3,292	5,003	5,693	5,475	4,534	4,090	3,878	3,601	3,490	2,090	3,801	48,572
....	3,360	2,072	4,045	3,174	3,773	3,759	4,394	4,199	3,916	4,000	2,205	1,473	40,370
....	2,100	2,952	3,810	5,009	5,569	4,713	4,321	4,476	3,779	3,895	2,613	2,726	45,963
....	2,333	2,590	4,136	4,914	3,350	4,168	3,224	3,312	3,793	3,746	3,166	2,984	41,716
....	3,257	4,075	4,662	4,443	4,613	4,875	4,023	3,492	3,844	3,947	2,422	5,410	49,063
....	2,410	2,378	2,770	3,006	2,652	3,853	4,366	3,921	3,584	2,823	3,705	2,808	38,276
....	3,520	2,822	3,736	4,319	4,534	4,146	4,287	3,210	3,734	4,193	2,730	2,239	43,470
....	3,862	5,350	3,933	4,877	4,926	4,589	3,800	4,524	3,723	3,414	2,863	3,406	49,267
....	3,776	3,201	4,736	4,160	4,562	4,989	4,123	4,333	2,947	3,619	2,648	2,441	45,535
....	2,256	2,229	4,180	4,758	4,920	4,402	4,808	4,309	3,567	3,430	2,857	4,539	46,255
....	4,095	3,920	4,232	4,196	4,272	4,507	3,602	3,279	2,806	2,745	2,008	2,201	41,863
....	2,217	4,320	3,300	3,761	4,205	4,135	3,618	4,041	4,860	3,798	3,261	4,368	45,884
....	2,474	2,234	4,935	3,954	3,952	4,501	5,039	4,355	4,313	3,778	5,377	3,612	48,524
....	3,695	3,822	4,810	5,741	5,729	5,173	4,532	4,196	4,973	3,876	3,775	3,256	53,578
....	4,135	4,305	5,273	4,958	5,387	4,836	4,167	4,358	4,401	4,366	3,187	4,132	53,505
....	4,571	2,947	5,886	5,638	5,513	4,559	4,464	4,134	5,140	3,966	3,512	3,804	54,134
....	4,274	3,601	4,382	5,710	4,963	4,460	4,108	4,185	5,002	4,234	4,166	3,239	52,324
....	2,662	3,742	5,490	5,215	5,020	4,663	4,687	4,238	4,637	4,376	3,557	3,436	51,723
....	3,169	3,460	5,148	5,018	4,539	4,733	4,334	4,486	4,432	3,878	3,679	3,799	50,675
....	4,449	3,343	5,044	5,356	5,058	4,664	4,348	4,913	3,748	.....	.....	.....	*a* 40,923
	81,139	81,231	111,542	121,212	123,267	117,053	111,134	108,793	105,264	92,867	78,193	79,091	1,210,777
erage	3,245	3,250	4,462	4,662	4,741	4,502	4,274	4,184	4,049	3,715	3,128	3,164	*b* 47,444

a For 9 months. *b* For 24 years.

HISTORY OF IRRIGATION.

Modern irrigation in the United States began in Salt Lake Valley, Utah, when the Mormons settled there in 1847. One of the first undertakings after reaching the valley was the diverting of the water of what is now known as City Creek and the irrigation of a few acres of land planted with seed brought with them on their long and perilous journey from Illinois.

Traces of irrigation antedating the Salt Lake Valley undertaking are to be found in Arizona in the systems (long since abandoned) of an extinct race of aborigines, and in southern California, where irrigation was practiced by the mission priests.

An historian of the Mormon Church describes the present site of Salt Lake City as follows:

> A desolation of centuries, where earth seemed heaven forsaken, where hermit nature—watching, waiting—wept and worshipped God amid eternal solitude.

Charles Brough, in his Historical and Political Studies on Irrigation in Utah, says:

> The transformation of this sterile waste, glistening with beds of salt, and soda, and deadly alkali, seemed impossible.

These quotations give an idea of how the conditions appeared to the first settlers. In the year 1848, 5,153 acres were put under irrigation,

and the amount of land under irrigation in this locality has since rapidly increased. The growth of Salt Lake City was very rapid, and in 1850 the population numbered 11,354. During this year there were over 16,000 acres under cultivation. In 1852 the assessed value of property was $400 per capita. To-day the city possesses a population of 70,000. The broad streets are lined with rows of stately trees and the comfortable homes are surrounded by luxuriant lawns.

The rural districts are populous; the farms are small and are characterized by an intensive and diversified form of agriculture. In the whole State of Utah the average size of the irrigation farms is 27 acres.

According to statistics gathered in 1894 by the State statistician, there were 2,195 farms in Salt Lake County, 90 per cent of which were cultivated by the owners. Of the total number of farms only 14 per cent were incumbered by mortgage.

Notwithstanding the success that has been attained, serious damage has occurred in places through the accumulation of seepage waters and alkali. Districts once successfully farmed have been abandoned and the attempts at reclamation have failed, because suitable methods have been wanting. Damaged lands are more apparent now than formerly, and demand for methods of preventing such damage and for reclaiming waste land is greater than ever before.

The earliest irrigation was principally on the east side of the Jordan River, the irrigation waters being obtained from the numerous small streams issuing from the canyons of the Wasatch Mountains. The canals, always small, were constructed by cooperative labor, cooperation being the watchword of the Mormons and even to the present time predominating in all lines of mercantile pursuits.

A number of farmers owning land along a stream joined together and by their collective labor constructed a canal that brought water to all of their farms. The distribution of the water was proportional to the amount of land owned by each. The advantage of this method was that it gave water to each farmer without expenditure of money and without waiting. The canals were crudely constructed and no provision was made against leakage. Water was turned into the canals in the spring and not turned out until fall, in some instances even running throughout the year. As a result the large amount of waste and seepage waters did much damage to lands lying below the neighborhood irrigated, and at the present time a large area of land immediately south of Salt Lake City and adjacent to the river is much affected by seepage waters and alkali.

On the west side of the Jordan River the earliest attempts at irrigation were on the Jordan meadows or river bottom lands, the water supply being obtained from the Jordan River by means of small canals. Subsequently the Brighton and North Point and the North Jordan canals were run upon the first terrace above the river, and following these were the South Jordan and the Utah and Salt Lake canals on the second and third benches, respectively.

As is frequently the case, the irrigation on the benches caused an cumulation of seepage and alkali on the river bottom land, so that uch of it has been abandoned. The largest and most seriously dam-ged area, however, is just south of Twelfth Street road, and comprises strip of land varying from half a mile to a mile and a half in width, id extending 10 miles west from the river. Here the seepage and irplus waters from the outer extremities of the Utah and Salt Lake, ie South Jordan, and the North Jordan canals have collected to an larming extent. Indeed, the damage has gone so far that a chain of kes has formed, presenting a water surface of fully 1,000 acres. The rea affected is not less than 10 square miles.

That portion of Salt Lake Valley west of the Jordan River which s at present under irrigation includes about 40 square miles, and overs a strip about 2 miles wide, bordering on the river and extending hrough Ts. 2 and 3 S., R. 1 W., together with another narrower por-ion at the north, which bends to the west through T. 1 S., Rs. 1 and 2 W., nearly to the point of the mountains. It consists mainly of ter-aces, one above another, and has a slope toward the river or to the orth of 50 to 100 feet per mile.

In addition to the above-named canals there is the surplus canal, rom which the North Point Consolidated Canal is taken. The latter conducts water to the low-level area north of the base line, but is little used for irrigating purposes because of the unsatisfactory results of applying water to this level, salty land.

The irrigation canals on this side of the river have an aggregate capacity of about 600 cubic feet per second, but less than half of this amount is required or used on the 25,000 acres under cultivation. On the low-level area, between Salt Lake City and the lake, many attempts have been made and much money expended in the endeavor to success-fully irrigate the land; but, with a few minor exceptions, the attempts have all proved failures.

The canals are owned, for the most part, by the owners of the land under irrigation, and the only paid officer is the "water master," whose duty it is to attend to the equitable distribution of the water to the shareholders. At stated intervals, along the main canals, laterals are taken out to supply the farms along its course. Each lateral has a head gate, the opening or closing of which is controlled by the water master, and the size of the opening is varied according to the number of shares supplied by the lateral and the total water supply for the canal. If the water supply is plentiful, the gates usually remain with a certain-sized opening throughout the season, and the water is per-mitted to flow continuously. Each shareholder is entitled to use all of the water flowing in the lateral for a stated number of hours and at stated intervals, according to a schedule agreed upon at the beginning of the season.

SOILS.

The area surveyed in 1899 includes all of that part of Salt Lake Valley lying west of the Jordan River, and is equal to about two-thirds of the entire valley. It extends westward to the foothills of the Oquirrh Mountains and the Great Salt Lake and northward to the lake. The area, roughly estimated, is 14 miles east and west by 28 miles north and south at its greatest extremes, and includes over 250 square miles.

Topographically the area varies in elevation from the present level of the lake, which is 4,170 feet above sea level, to about 4,700 feet at the foothills. A contour taken 50 feet above the lake would include the northern half of the district, which is comparatively level. The portion above such a contour inclines toward the mountains at the rate of from 50 to 100 feet per mile. The drainage is into the Jordan River or directly into the lake.

The soils have been formed by material brought down from the mountain sides and by sediments from the ancient Lake Bonneville, all of which have been materially modified by inflowing streams from the mountains and by the vacillating shore of the lake. Soils formed in this way are usually heterogeneous, and these soils form no exception to the rule. In the lower part of the valley the sediment is very deep, no rock or gravel being found at a depth of a hundred or more feet. As we get near the foothills, gravel and rock are plentiful and often crop out at the surface. Here there is little or no lake sediment apparent.

The soils are fertile, but in the natural condition support only a meager vegetation, because they are either too dry or too salty. On the higher portions, where there is little salt present, sagebrush forms the chief growth, while in the lower areas, where there is more moisture and much salt, salt-loving perennials, such a greasewood and "mutton sas," abound.

The following classification of the soils is based on the judgment of the field experts, typical samples of the various types being sent to the laboratory and analyzed, not as a basis for classification, but in order to obtain an explanation of certain characteristics as they appeared in the field.

The chief basis of the classification is texture, as determined by the feeling and appearance of the soil, and it will be seen by studying the analyses of samples of the different types that the judgment of the experts is quite as accurate as the analysis itself.

The classification is based chiefly on the characteristics of the first foot in depth of the soil, although the underlying stratum is sometimes considered, as in the case of the Bingham gravelly loam, where the gravel is sometimes absent in the top foot, but occurs in the second or third foot.

The soils have been classified under eight types, in the order of the magnitude of their respective areas, as follows:

1. Jordan sandy loam.
2. Bingham gravelly loam.
3. Jordan loam.
4. Jordan clay and clay loam.
5. Jordan meadows.
6. Jordan sand.
7. Bingham stony loam.
8. Salt Lake sand.

JORDAN SANDY LOAM.

This loam, shown on the soil map by the orange color, comprises about 30 per cent of the entire district, and is the most important of the various types of the soil, both in extent and quality. It is a light, sandy loam, varying from one to several feet in depth, the texture of which is shown in the accompanying table of mechanical analyses.

Mechanical analyses.

No.	Locality.	Description.	Salt as determined in mechanical analysis.	Moisture in air-dry sample.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to .1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.01 mm.	Fine silt, 0.01 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
	Jordan sandy loams 0 to 12 inches in depth.		*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
4303	SW. ¼ sec. 17, T. 1 N., R. 1 W.	Dry level land..	0.49	1.18	1.84	0.16	4.17	11.40	27.87	17.76	23.49	2.64	8.79
4311	SE. ¼ sec. 31, T. 2 N., R. 1 W.	Low level land.	.41	.94	2.17	1.10	3.28	7.80	15.23	23.46	33.06	2.80	9.47
4309	C. sec. 24, T. 1 S., R. 2 W.	Dry level land..	1.69	1.62	9.20	0.00	.12	.61	26.87	23.55	23.30	3.59	10.87
4369	S. C. sec. 17, T. 1 S., R. 1 W.	.....do.....	1.50	1.45	3.31	T.	.28	.95	8.84	39.31	29.44	3.28	11.74
4310	C. sec. 20, T. 1 N., R. 2 W.	.....do.....	1.09	1.79	5.25	.13	3.96	9.61	20.13	16.43	26.36	2.59	13.37
4297	N. C. sec. 27, T. 1 N., R. 2 W.	.....do.....	.89	1.55	4.57	.18	3.42	10.01	23.74	15.65	24.38	2.80	13.55
4365	NE. C. sec. 16, T. 2 S., R. 1 W.	Alfalfa, irrigated.	.30	1.95	5.42	T.	.77	4.98	3.11	26.82	35.85	3.87	14.58
4366	S. C. sec. 1, T. 1 S., R. 2 W.	Trees, irrigated.	.44	1.27	4.05	.67	1.06	1.43	9.11	29.85	33.08	4.75	15.03
	Subsoils under Jordan sandy loams.												
4370	Loam 24 to 36 inches.	Under 4369.....	1.08	1.49	5.61	T.	.48	1.63	8.61	27.12	29.42	2.60	22.43
4371	Sandy loam 36 to 60 inches.	.....do.....	.66	.99	4.24	.....	T.	.82	5.90	42.41	30.33	2.79	13.10
4367	Loam 12 to 24 inches.	Under 4366.....	.44	1.27	5.16	.35	1.11	1.40	5.84	30.05	31.11	5	18.21
4368	Fine sand=sandy loam 24 to 48 inches.	.....do.....	.46	.90	3.94	T.	.31	.34	3.10	46.38	32.82	2.72	9.54

The analyses of the eight samples of soil in the above table, the samples being taken from the first foot in depth, probably represent the range in texture for this type of soil. The clay content is comparatively low, ranging from a minimum of 8.79 per cent to a maximum of 15.03 per cent with a mean of about 12.2 per cent, which may be taken as representing the average clay content of this type of soil. By far the larger part of the separations occur under the heads of very

fine sand and silt, which give an average of 24.1 and 28.6 per cent, respectively.

The soil varies somewhat in underlying strata, but the most usual profile is 2 feet of sandy loam, 1½ feet of loam, and 1 foot of fine sand, underlaid by clay to considerable depth. In the above table Nos. 4370 and 4371 show the texture of the loam and sandy loam (the latter approximating very fine sand) which underlie soil No. 4369, while Nos. 4367 and 4368 represent the loam and fine sand underlying soil No. 4366. The clay, which usually occurs at a greater depth than these samples represent, corresponds in texture to the analyses given for the same under Jordan loam on page 95. Subsoils of this texture permit a ready movement of the ground water, and should therefore be easily underdrained by placing lines of tiles 150 feet apart.

As a rule the Jordan sandy loam overlies the Jordan loam, on which it generally borders, and it occurs mostly in the irrigated district and the low land to the north. That portion of it lying above the irrigation canals, as well as that in the irrigated district wherever the water table is 10 or more feet below the surface, is free from any excessive amount of salts. On the low area to the north, however, it generally contains considerable salt, especially in the lower depths. The native vegetation on this part of it consists mainly of greasewood and shad scale (perennial bushes growing from 1 to 4 feet in height) on the drier and less salty portions; and of mutton sas, salt grass, and various small salt-loving annuals on the moist and more salty places.

The accompanying table shows the per cent of salt in solution when the soil is saturated with water for various depths and places in the Jordan sandy loam, the percentage being calculated on the water-free soil.

Table showing the soluble salt content at saturation for various places and depths in Jordan sandy loam.

Number of boring.	Depth, in feet.									Depth to standing water.
	1.	2.	3.	4.	5.	6.	7.	8.	9.	
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Feet.*
200	0.06	0.05	0.05	0.06	0.08	0.08	0.10	0.11	0.11	10+
206	.06	.05	.06	.05	.09	.15	.....	.....	.....	20
16	1.51	1.17	.74	.50	.62	.72	.....	.....	.....	4
99	.76	.63	.40	.35	.29	.28	.....	.....	.....	3½
300*a*	.18	.15	.19	.25	.25	.20	.....	.....	.....	4
651	.35	.....	1.02	.....	1.06	.....	.....	.....	.....	4
629	.11	.54	.88	*b*.33	*b*.35	1.64	.....	.....	.....	6+
644	.14	.68	1.01	1.12	1.39	2.00	.....	.....	.....	6+
517	.40	.....	.76	.....	1.04	.....	.....	.....	.....	7
626	.09	.48	.85	1.10	1.54	2.22	.....	.....	.....	6+

a Irrigated. *b* Sand pocket.

Borings Nos. 200 and 206 represent about the mean salt content of this type of soil on the good irrigated land. Here the salt rarely exceeds 0.1 per cent above a depth of 5 feet. While there is a gradual increase in the salt as we go down, it never occurs to an alarming

NATURAL VEGETATION OF GREASEWOOD AND SALTBUSHES ON JORDAN SANDY LOAM.

[illegible] in the natural state is adapted only to the grazing of sheep.

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extent, although there may be sufficient to wash out into seepage areas below, and thus cause damage by its accumulation.

Borings Nos. 16, 99, and 651 show the condition on the low land where the water table is within 4 or less feet of the surface. Here there is a comparatively large amount of salt present and Nos. 16 and 99 show an accumulation in the surface foot, which is usually the case when the water is 3 feet or less below the surface. These borings were made during the driest part of the year, and it is probable that the water table is nearer the surface during the time of the year when more rain falls.

Boring No. 300 is in a favorable location on the low land where the water, before irrigation was undertaken, was nearly 10 feet below the surface. It has been irrigated for three years and is now planted in trees. The salt content is fairly uniform in its distribution and, while not present in great quantity, there is sufficient to cause serious trouble if allowed to accumulate in the surface portion of the soil. This it is likely to do if the water table rises much above its present level.

Borings No. 629, 644, 517, and 626 are representative of the amount and vertical distribution of the salts for the unirrigated low-land part of this type of soil, where the depth to standing water is 6 or more feet, which is usually the case. In these samples the aggregate amount of salt to the depth of 6 feet is considerable and will correspond to the area shown on the map by an appropriate color, where the salt content to a depth of 5 feet ranges from 0.6 to 1 per cent. A small portion of this type of soil, however, falls within another area on the map, where the salt content exceeds 1 per cent, while, on the other hand, some of it falls in the blue area, with less than 0.6 of 1 per cent. The first foot usually carries a relatively small amount of salt and indicates that crops could be successfully grown. As we go deeper, however, the amount of salts increases very rapidly and the second foot is usually about the limit for alfalfa, while the third foot almost invariably contains too much to permit the growth of any agricultural crops. At 6 feet there is usually about 2 per cent of salt.

This distribution of the salts probably occurs because the rains wash them downward more rapidly than they are returned toward the surface by evaporation. If irrigation water were applied, the salts would continue to move downward, provided the water table remained at its present depth. Unfortunately, however, the application of water invariably causes a rise of the water table, and if the application be continued over a considerable area the water table comes sufficiently near the surface to cause excessive surface evaporation, which results in an upward movement of the salts and their consequent accumulation at the surface. The present surface conditions as regards the amount of salt are fairly good over considerable areas, but in order to improve or even maintain these conditions under irrigation thorough underdrainage is imperative.

The Jordan sandy loam is easily cultivated and is sufficiently fertile to produce almost any class of crops. It forms the most valuable portion of the low salty area, because of the ease with which it may be reclaimed by underdrainage and washing. Owing to the light texture of the subsoil, the lines of drains could be farther apart than in the heavier soils, and it would therefore be less expensive to drain.

The diagram on page 93 (fig. 9) shows sections in various directions in the valley and illustrates the constitution of the soils to a depth of 6 feet.

BINGHAM GRAVELLY LOAM.

This type of soil is next in extent to the Jordan sandy loam, and comprises 60 square miles, or 24 per cent, of the entire district. Excepting about 2,000 acres immediately under the Utah and Salt Lake Canal, principally in the southern part of T. 1 S., R. 2 W., it all lies above the irrigation canals and is too elevated to be irrigated by any of the present water supply. There has been a scheme proposed for raising part of the water passing through the Jordan Narrows by hydraulic means and constructing another canal above and parallel with the Utah and Salt Lake Canal. The height to which it would be profitable to raise water for irrigation purposes by such means would take in only a narrow strip of this upland, owing to the steepness of the slope toward the mountains.

At Herriman there are about 100 acres irrigated by water taken from Butterfield Creek, and in the northwestern part T. 2 S., R. 2 W., there are a few small springs which serve to irrigate a very limited area. There are also a few small farms along Bingham Creek irrigated by its waters.

During freshets considerable water comes down from the canyons of the Oquirrh Mountains, and, in a few instances, some of it is diverted and used for irrigation. This, however, is very unsatisfactory, because at times when water is most needed no water is to be had. The only possible means of successfully irrigating any considerable area of this land is by storing the water from the mountain streams in reservoirs constructed for that purpose.

The Bingham gravelly loam comprises the area shown on the soil map by the brown color. It is always underlaid by gravel at within 3 feet of the surface, and the small gravel generally papears at the surface in greater or less quantities.

The following table gives the mechanical analyses of four samples of this soil to 12 and 15 inches in depth.

BINGHAM GRAVELLY LOAM—GRAVEL 1 INCH IN DIAMETER.

This type of soil in dry farmed to wheat and in favorable seasons produces fair yields.

The annual precipitation in the mountains is greater than in the valleys, and it is estimated that it includes 6 feet of snow, which lingers on the mountains the greater part of the summer. This is important in relation to irrigation, because it makes the water supply plentiful throughout the season.

The annual evaporation from a free water surface in Salt Lake Valley is estimated at 8 feet. Data from one of the salt companies show the evaporation from their ponds to be about 37 inches from June to September, inclusive. It should be borne in mind, however, that this is from a saturated salt solution and that the presence of much salt lowers the vapor tension, and, consequently, the rate of evaporation. The evaporation from a fresh-water service would no doubt have been much greater.

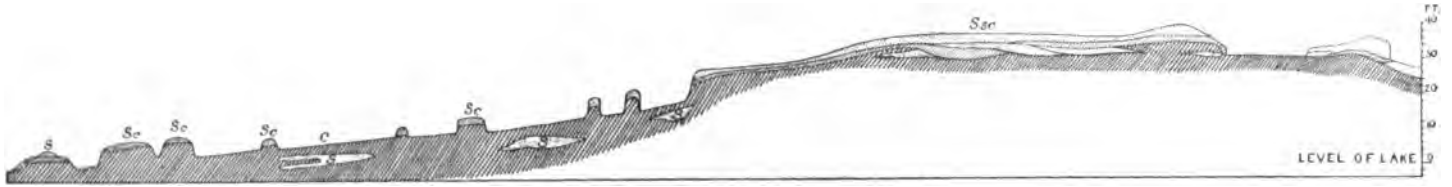
The mean annual temperature is 51.2° F., with a mean maximum of 75.6° in July and a minimum of 27.9° in January. The mean temperature for from June to September, inclusive, is 70.5° F.

The following table gives the mean monthly and yearly temperature for the past twenty-five years.

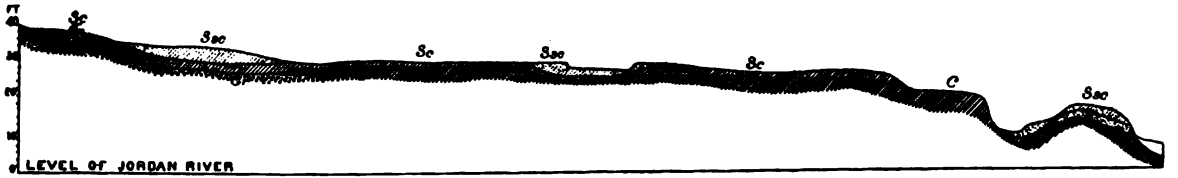
Mean monthly and mean annual temperature, Salt Lake City, Utah, from 1874 to 1899.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1874	.....	.....	.....	.....	.....	67.1	77.8	74.6	62	56.4	43.2	33.9	.....
1875	29.5	34.2	35	48.9	59	67.8	74	75	68.1	58.2	42	36.2	52.4
1876	30.5	36.1	37.2	49.8	56.7	68.6	76.5	71.6	65.8	55.3	41	27	51.2
1877	27.2	34.1	46.9	48.8	56.2	65.4	77.4	75.8	64.4	51.6	40.6	32.1	51.4
1878	30.3	37.8	47.1	49.4	56.4	68.5	76.9	78.4	60.6	49	44	29.8	51.9
1879	28.3	39.6	49.2	52.6	58.2	65.2	76.8	75.4	68.5	52	36	29.4	53
1880	28.2	26.2	34	46.8	54.2	66	74.2	72.8	63.6	52	29.6	34.6	48.6
1881	30.8	38.2	42.2	54.2	60.2	71.2	76	74.4	60.2	50.8	33.8	33.6	51.8
1882	23.5	26.9	36.6	46.7	57.2	67.3	75.4	76.9	64.8	48.4	35.5	35	49.2
1883	24.4	24.1	47	45.6	56.7	70	76.2	76.8	69.7	46.3	39.2	32.5	50.8
1884	28.4	30.7	40.8	48	57.9	69.1	74	72.7	59.4	53	42.2	35.2	51.4
1885	27.6	36.8	45.6	53.5	56.6	64.8	76.1	73.7	65.1	54.9	43.8	33.9	52.3
1886	28.8	40.8	37.7	48.4	62.4	68.9	78.1	76.1	62.8	51.8	31.4	36.1	51.6
1887	33.2	34.1	47.2	49.2	60.8	68.6	74.9	73.4	65.5	51.6	42.8	29.2	52.7
1888	22.9	38.3	40	54.8	58.6	68.4	76.6	74.8	70.6	54	41.6	35.8	53
1889	21.4	29.8	47.7	55.2	58.8	70.3	78.4	77.4	60.6	54.2	39	39.6	52.7
1890	24.8	33.7	39.5	50.4	61.3	64.8	77.8	72.9	65	48.6	41	36.2	51.6
1891	28.8	30.6	38	49.6	60	62	73.3	74.4	65	53.2	44.2	28.6	50.6
1892	25.8	33.6	43.4	47.4	55.4	65.8	76	75.4	69.6	51.8	42.2	27.6	51.2
1893	27.6	28.5	39.3	45.9	55.1	67	74.7	73.3	63	52	39.4	36.3	50.2
1894	29	25.6	41.1	48.1	61.2	63.9	74.6	75.4	61	53.2	45.6	31.4	50.8
1895	29.7	30	40.8	51.2	57.9	63.5	72.6	74.8	63.8	54.3	37.8	26.4	50.2
1896	34	36.8	40.2	46.4	51.4	70	74.2	73.7	64	54.4	37.2	36.2	51.5
1897	28.8	30.9	33.6	49	63.4	66	71.9	75.2	62.2	50.9	43.2	27.4	50.2
1898	20.6	35.6	36.3	54	53.9	67.1	75.9	76.8	65.6	48.2	37.3	25.2	49.7
1899	33.8	29.6	40.6	50.6	52.6	65.1	76.2	69.8	67.1	.....	.....	.....	.....
Average	27.9	32.9	41.1	49.8	57.7	67	75.6	74.7	64.5	52.2	39.7	32.4	51.2

The mean annual wind movement is at the rate of 5.4 miles per hour, with a maximum of 6.4 miles in May and a minimum of 4.3 miles in November.



Section A–A.



Section B–B.

Section C–C.

FIG. 9.—Sections in Salt Lake Valley along lines marked on sketch map, page 103. (*S* = sand; *Sac* = sandy loam; *Sc* = loam; *C* = clay; *Gr* = gravel.)

Mechanical analyses of Bingham gravelly loam soils.

No.	Locality.	Description	Moisture in air-dry sample.	Organic matter.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.01 mm.	Fine silt, 0.01 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
4362	SW. ¼ sec. 15, T. 3 S., R. 2 W.	Rolling land 0 to 15 inches, 25.5 per cent coarse gravel.	2.25	3.96	1.50	2.71	5.81	8.87	27.93	28.06	5.13	13.51
4363	S. C. sec. 24, T. 2 S., R. 2 W.	Rolling land 0 to 15 inches, 9 per cent coarse gravel.	2.90	4.16	0.66	1.77	7.71	8.50	28.71	22.19	4.38	15.98
4312	SW. ¼ sec. 2, T. 2 S., R. 2 W.	Rolling land 0 to 12 inches, 54.5 per cent coarse gravel.	2.39	4.53	7.57	2.64	2.88	7.29	13.06	37.12	4.34	18.15
4313	SE. ¼ sec. 34, T. 3 S., R. 2 W.	Rolling land 0 to 15 inches, 4.4 per cent coarse gravel.	3.04	5.06	.33	.77	2.48	4.09	15.73	38.91	5.08	22.68

The analyses show the texture of the fine earth after all gravel larger than two millimeters in diameter has been taken out. The clay ranges from 13.5 to 22.6 per cent of the fine earth. The coarse gravel varies from 4.4 to 54.5 per cent. The gravel is small and more or less rounded and interferes little with the cultivation of the soil. Below 3 feet, and sometimes at even a less depth, the gravel becomes large and occasionally gives place to bowlders and rock. The most usual profile to 6 feet in depth is 18 inches of gravelly loam, underlaid by large gravel. This type of soil is usually free from noticeable amounts of salt, as will be seen by referring to the salt map. The native vegetation consists largely of sagebrush, with some rabbit bush, grass, tumble weeds, etc.

A considerable percentage of this type of soil is dry farmed to wheat. As a rule, the yield is small, but in years of abundant rainfall it sometimes exceeds 20 bushels per acre. The land slopes rapidly toward the mountains and has many deep washouts, which seem much larger than would be required for the natural escape of the drainage waters. These were probably formed by cloudbursts, which at some period visit most of the areas in the Bonneville Basin.

JORDAN LOAM.

This type of soil, while ranking third in extent, is perhaps second in importance, as it mostly lies within reach of the present irrigation water supply. It comprises about 50 square miles, or 20 per cent of the total area, and four-fifths of it lies below the present canal systems. Of this portion, however, there are numerous isolated areas, occurring in the area of clay flats near the shore of the lake, which, owing to their irregular forms, small size, and location would be relatively expensive to irrigate. The main body of this type of soil, how-

ver, could be easily irrigated and, as demonstrated by that portion ow under cultivation in the irrigation district, would prove excellent nd if put in proper condition.

This type of soil is shown on the soil map by the areas in solid red. t varies much in depth and underlying strata; the most usual profile, owever, is 3 feet of loam, underlaid by clay which contains frequently ockets or strata of sand.

The accompanying table of mechanical analyses shows the texture of he surface foot in six localities and the character of the subsoil underying two of them.

Mechanical analyses of Jordan loams.

No.	Locality.	Description.	Salt as determined in mechanical analysis.	Moisture in air-dry sample.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.05 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.01 mm.	Fine silt, 0.01 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
4331	NW. C. sec. 34, T. 1 N., R. 2 W.	Dry level land..	0.80	1.49	3.72	0.31	0.61	2.51	7.03	26.95	37.42	4.	14.70
4318	S. C. sec. 27, T. 3 S., R. 1 W.	Good alfalfa land irrig.	.56	2.30	5.05	.12	.16	.38	2.62	20.92	37.73	6.73	22.58
4324	S. C. sec. 18, T. 1 S., R. 2 W.	Low, wet by springs.	2.38	2.39	14.13	.10	.47	1.08	2.68	12.45	28.59	12.98	23.16
4325	NE. ¼ sec. 35, T. 1 N., R. 2 W.	Dry level land..	.81	2.35	4.89	T.	.17	.64	4.66	20.68	36.23	5.99	23.51
4364	N. C. sec. 4, T. 1 S., R. 2 W.	.....do.....	1.08	2.10	6.81	1.57	2.42	3.23	5.67	14.22	29.96	6.49	27.66
4326	NW. ¼ sec. 8, T. 1 N., R. 2 W.	Low uneven land.	1.76	1.07	8.57	T.	.56	1.25	7.45	33.70	12.46	1.06	31.80
	Subsoils under Jordan loams.												
4332	Loam 12 to 24 inches.	Under 4331.....	1.16	1.37	9.41	T.	1.47	2.10	6.53	24.81	30.58	2.38	21.04
4333	Very fine sand 24 to 36 inches.	.....do	.95	1.03	6.83	.....	.11	.66	7.78	42.67	27.04	1.85	11.91
4334	Sand and clay 36 to 48 inches.	.....do.....	1.25	.93	5.64	3.78	2.91	9.33	17.56	17.97	24.18	2.40	13.63
4335	Clay loam 48 to 72 inches.	.....do.....	1.59	2.18	8.16	1.26	.88	1.16	2.40	13.38	35.49	4.52	28.37
4372	Clay loam 12 to 24 inches.	Under 4364.....	1.74	2.64	9.22	.49	1.02	2.65	5.08	11.87	24.63	7.10	33.47
4372a	Clay loam 24 to 36 inches.	.....do.....	2.24	2.15	11.21	3.24	2.52	2.49	2.34	5.88	23.83	8.64	33.14
4373	Clay 36 to 48 inches.	.....do.....	2.24	2.10	10.23	T.	.41	.26	.41	7.33	24.46	9.23	44.38

The clay content varies from a minimum of 14.7 per cent to a maximum of 31.8 per cent. The latter amount is rather high to be classed as a loam, 30 per cent being usually taken as the upper limit for this class. This sample, however, was easily classed as a loam by the observer in the field, and the fact that it contains a lower percentage of silt and fine silt than any of the other samples analyzed for either this or the two preceding types of soil accounts for the apparent conflict between the analysis and the field judgment. The silt content, being unusually low, counteracts the effect of part of the clay, and therefore gives the sample the characteristics of loam. The mean clay content of 23.9 per cent for these six samples may be taken as representative of

this type of soil. The other large separations are under the heads very fine sand and silt, which give 21.5 and 30.4 per cent respectivel The first four separations show a very small percentage in any of t samples.

Samples Nos. 4332–35, inclusive, show the texture of the subsoil t feet in depth under soil No. 4331. The second foot is also a loam, b heavier than the first, which is on the border line between Jordan sand loam and Jordan loam; next comes very fine sand, which continu about two-thirds of the way through the fourth foot, and below this clay loam. This character of subsoil, while common under Jordan loa is perhaps more characteristic of the first type of soil.

Samples Nos. 4372 and 4373 show the texture of the subsoil under s No. 4364. Here the second and third feet are clay loam and the fourt foot clay. This is more characteristic of this type of soil than is t former subsoil, exceptiug that the overlying loam is of less depth tha the average. Subsoils of this character are so heavy that ordinari they would be rather expensive to drain, on account of the short interval at which lines of tiles would need to be laid in order to prove effective

The field observations here, however, show that the clay or clay loa subsoil is most usually inlaid by strata of fine sand varying from a fraction of an inch to a foot or more in thickness. While these strata are continuous for only short distances, yet they occur at such frequent intervals that they would undoubtedly be of material assistance if underdrainage were undertaken.

Soil No. 4324 occurs in an area wet by large springs and producing a luxuriant growth of salt grass, which accounts for the high percentage of organic matter. The apparently high percentage of organic matter in the heavier samples is probably in part water of crystallization, which is only driven off by temperatures higher than are required for moisture determinations.

On the lowland the Jordan loam lies slightly lower than the sandy loam. It has the water-table rather near the surface and carries a higher percentage of salt.

The accompanying table gives the percentage of salt in each foot to a depth of 6 feet for various places in this type of soil.

Table showing the per cent of salts at saturation at various places and depths in Jordan loam.

[Percentage calculated on water-free soil.]

No. of boring.	Depth in feet.							Depth to standing water.
	1.	2.	3.	4.	5.	6.	8.	
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Feet.*
275	0.07	0.07	0.08	0.09	0.10	0.07	.....	10+
149	.05	.05	.06	.07	.07	.....	.....	.....
447	.58	.23	.12	.19	.14	.18	.....	1
138	.49	.21	.18	.16	.16	.17	.....	2
127	.58	.41	.24	.15	.16	.16	.....	3
375	2.07	1.44	1.13	.86	.82	.92	.....	4
623	.11	.09	.28	.54	.88	81	0.67	5
624	.38	.95	1.17	1.38	2.04	2.36	.....	6
343	.74	1.38	1.65	2.09	2.09	2.21	.....	5
649	1.43	2.37	2.60	3.45	3.66	3.37	.....	6

Borings Nos. 275 and 149 are typical of the favorable conditions for his type of soil in the irrigated district. Nos. 447, 138, and 127 are epresentative of the conditions in the southern part of T. 1 S., R. 1 nd 2 W., where seepage water has caused an abandonment of the land r farming. Here the water table lies within 3 or less than 3 feet of the rface, and while the total salt content to a depth of 6 feet is only bout 0.25 per cent, yet in the surface foot it has accumulated to such a extent as to be fatal to some crops. By removing the water the il would soon return to a productive state.

Boring No. 375 is in a low level area which is watered by large prings. At the time this determination was made the water had been rned off, and the water table was 4½ feet below the surface. Ordiarily it is much nearer the surface than this, and, in fact, the surface frequently covered by water. The salt content is high and shows an ccumulation at the surface, this being always a result of wetness. os. 623, 624, 343, and 649 show the range in salt content and its usual istribution on the lowland part of this type of soil when the water ble is more than 4 feet below the surface. They all show the minium amount in the surface foot, and a gradual increase as the depth creases. No. 623 shows an unusually small amount, 649 an excessive mount, and 624 and 643 normal amounts for this type of soil.

A comparison of the soil and salt maps shows that most of this type f soil which is on the lowland falls within the slate colored area on the lt map—i. e., it contains from 1 to 3 per cent of salt to a depth of 5 et. Excepting about 2 square miles near the mouth of the Jordan iver, none of it falls into the class containing more than 3 per cent; ut on the other hand a small per cent falls in the class containing 0.6 o 1 per cent.

Like the Jordan sandy loam, this type of soil also frequently shows a omparatively small amount of salt in the surface foot, but as we escend it increases rapidly, and when the soil is put under irrigation he salts soon accumulate at the surface, unless by some means the ater table is kept down and the surface evaporation reduced to a minium by the best cultivation or by shading crops.

The larger percentage of this type of soil is capable of reclamation y underdrainage and washing, but at a somewhat greater outlay than ould be required for the Jordan sandy loam.

JORDAN CLAY AND CLAY LOAM.

The next type of soil in order of extent is the Jordan clay and clay oam, which comprises about 35 square miles, or 14 per cent of the hole area. Excepting about 1,500 acres, one-half of which lies west f Williams Lake and the remainder southwest of Decker Lake, this ype of soil lies from 4 to 8 feet lower than the land immediately adjoing. It is level and wet, and rarely contains any vegetation. It forms hat was formerly the floors of lagoons near the shore of the lake and

often extends far back into the higher and better land. In other place it assumes the form of draws extending like wide irregular canals ba into the land for miles. Its distribution is shown on the soil map b the blue color.

The accompanying table gives the mechanical analyses of two sampl of soil and the subsoil under one of them to 6 feet in depth.

Mechanical analyses of clay and clay loam soils.

No.	Locality.	Description.	Salt as determined in mechanical analysis.	Moisture in air-dry sample.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.01 mm.	Fine silt, 0.01 to 0.005 mm.	Clay, 0.005 to 0.0001	Fi...
			Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Pe...*
4345	C. S. 18, T. 1 N., R. 2 W.	Salt flat	8.89	...	11.51	3.94	4.91	2.92	2.28	14.10	19.15	4.23	25.	
4351	S. 30, T. 1 N., R. 1 W.	Low level land	2.04	2.63	6.39	.77	.90	2.03	4.37	20.68	27.46	4.35	28.	
	(*Subsoil under 4345.*)													
4346	Depth 12 to 24 inches.	Clay loam	11.47	2.10	13.65	7.19	6.17	4.94	3.52	7.28	22.78	4.47	16.	
4347	Depth 24 to 36 inches.	Yellow clay	7.82	11.02	12.96	4.14	1.88	2.66	1.16	5.47	23.53	3.45	26.	
4348	Depth 36 to 48 inches.	Red clay	5.92	8.24	8.43	2.58	1.06	.64	.54	8.41	27.19	3.74	25.	
4349	Depth 48 to 60 inches.	.....do	6.53	10.20	9.50	8.58	.41	.23	.28	3.27	24.02	3.38	33.	
4350	Depth 60 to 72 inches.	.....do	5.02	.....	5.32	.51	.29	.32	.50	14.42	30.04	10.	33.	

Sample No. 4351 shows the texture of the small upland area just wes of Williams Lake. It is very similar to the Jordan loam, which lie adjacent, but is slightly lower and somewhat heavier in texture. It salt content to a depth of 6 feet is shown under boring No. 162 in th table giving salt content. The total salt content does not differ mate rially from that in the adjacent Jordan loam, but it shows an accumu lation in the upper portions, which is not the case with the latter where the water table lies at 6 feet, as it does here. The probabilities are that the water table is much higher under this soil during a portion of the season.

No. 4345 shows the texture of the clay loam of the flats, 20 per cen of this sample being under the heads of organic matter, and sal Therefore the clay content should be increased from 25.67 to over 3 per cent, in order to show the real per cent of clay present in the so alone. The subsoil beneath this is shown in Nos. 4346–50.

The accompanying table shows the per cent of salt for this type of soil:

Salt content at saturation for various places and depths in Jordan clays and clay loams.

[Percentage calculated on water-free soil.]

Number of boring.	Depth in feet.										Depth to standing water.
	1.	2.	3.	4.	5.	6.	8.	10.	12.	15.	
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Feet.*
12	0.14	0.11	0.12	0.13	0.12	0.12	.....	.....	.....	.....	2
12	1.18	1.23	1.12	.79	.68	.....	.....	.....	.....	.....	6
15	5.58	4.95	6.30	6.41	5.22		4.44	2.96	1.86	.88	3
15	4.50	5.06	6.03	.....	7.82	.....	.....	.....	.....	.....	1½
16	10.60	9.80	11.40	10.30	9.80	9.30	.....	.....	.....	.....	2

Boring No. 132 gives the salt for each foot to 6 feet in depth for the area southwest of Decker Lake. The water table at the time of making this boring was only 2 feet below the surface, but the determination shows only a slight tendency to an accumulation of salt at the surface. In other portions of this area, however, the accumulation of the salt at the surface has caused the land to be abandoned.

Nos. 355, 645, and 646 give the salt content for three places in the barren clay loam and clay flats, and the amount present is simply astonishing. The above determinations show a range of from 4.5 to 11.4 per cent of salt in solution at saturation in the upper 6 feet of soil, and it is probable that at such concentration some of the salts may remain undissolved and are therefore not shown by the electrical method, which was used in their determination. Below 6 feet in depth there is a gradual diminution in the salt content, and in boring No. 355 it is only 0.88 per cent at 15 feet in depth. Boring No. 646 shows a very high salt content, the average to 6 feet in depth being 10.2 per cent. Allowing 70 pounds as the weight of a cubic foot of this soil, the amount of salt present, to a depth of 6 feet, in one square mile would amount to approximately 1,200,000,000 pounds. To the average mind such large numbers give no adequate idea of the real amount. By reduction we find that the 1,200,000,000 pounds equal 600,000 tons, which, at the rate of 20 tons each, would fill 30,000 cars. At 20 cars to the train this would equal 1,500 trains, or a continuous train of cars 180 miles long.

The agreement in area of this type of soil and the areas on the salt map showing 3 or more per cent of salt is almost identical. This type of soil being low, wet, salty, and of a clay nature, is not worthy of any notice for agricultural purposes at the present time. Those parts of it that extend far back into the better land form good drainage outlets for the latter and with very little improvement would serve to conduct drainage water to the lake.

JORDAN MEADOWS.

The Jordan Meadows comprise about 12 square miles, or 4.8 per cent of the entire area. They lie as a narrow strip, from a few rods to three-quarters of a mile in width, bordering on the Jordan River, and their usual elevation is only a few feet above the water in the river. Both the soil and the subsoil vary much in texture. The soil, however, is generally either a sandy loam or a loam about 2 feet in depth, which is underlaid by 2 feet of clay and this in turn is underlaid by sand and gravel. The soil is usually black, on account of the large amount of organic matter that it contains.

The following table shows the mechanical analyses of the soil from three places:

Mechanical analyses of Jordan Meadows soils.

No.	Locality.	Description.	Salt as determined in mechanical analysis.	Moisture in air-dry sample.	Organic matter.	Gravel 2 to 1 mm.	Coarse sand 1 to 0.5 mm.	Medium sand 0.5 to 0.25 mm.	Fine sand 0.25 to 0.1 mm.	Very fine sand 0.1 to 0.5 mm.	Silt 0.05 to 0.01 mm.	Fine silt 0.01 to 0.005 mm.	Clay 0.005 to 0.0001 mm.
			Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
4338	W. C. sec. 22, T. 1 N., R. 1 W.	River bottom, 0 to 24 inches.	1.05	1.18	5.90	T.	3.71	8.42	15.91	36.07	15.75	1.74	9.65
4337	SW. C. sec. 14, T. 1 S., R. 1 W.	River bottom, 0 to 12 inches.	1.96	1.89	9.23	T.	1.57	1.72	7.16	31.30	26.76	3.34	15.53
4339	E. C. sec. 14, T. 3 S., R. 1 W.	River bottom, 0 to 12 inches.	1.68	4.85	11.61	.21	.82	3.01	6.87	19.41	20.84	5.96	16.93

This type of soil was the first irrigated on the west side of the river, but wherever irrigation has been practiced above this land the seepage waters have come down and caused much damage. At present very little of it is farmed, but it often furnishes good pasture.

The accompanying table gives the salt content to a depth of 6 feet in three localities. The salt while not present in excessive amounts is sufficiently high to be harmful and is sometimes even fatal to ordinary crops. There is a tendency for it to accumulate at the surface.

Salt content at saturation for various depths and places in Jordan meadows.

[Percentage calculated on water-free soil.]

No. of boring.	Depth in feet.						Depth to standing water.
	1.	2.	3.	4.	5.	6.	
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Feet.*
5	0.37	0.76	0.40	0.31	0.36	0.35	3½
637	0.55	0.51	0.49	0.55	0.35	0.30	6
281	0.73	0.67	0.36	0.29	0.27	0.18	5

JORDAN SAND.

These sands constitute a marginal area along the bluffs just above the Jordan meadows, and are found in a few isolated areas on the upland. They are shown on the soil map in yellow. It is fine sand

nually to a depth of 6 feet or more, although occasionally occurring as a overlying stratum only 1 or 2 feet in depth, covering sandy loam or am. In places it drifts about as dunes, and is usually so located as) be difficult to irrigate, therefore it is not much used for agricultural urposes. Where irrigated it requires large amounts of water to cover ny considerable distance, and as a consequence, accumulations of eepage waters on low adjacent areas are the rule. Owing to the leachy haracter and good underdrainage, it seldom contains much salt.

BINGHAM STONY LOAM.

This loam occurs above all canals, and constitutes a small area near he foothills of the Oquirrh Mountains, shown on the soil map by the rown color. It consists of a thin layer of sandy or gravelly loam, underaid by bowlders, rock, and conglomerate, which frequently outcrops, rom a few inches to the height of a man, at the surface. It is too stony or cultivation.

SALT LAKE SAND.

This sand is a product of Great Salt Lake, and consists of spherules about the size of No. 10 shot, which are made up almost wholly of carbonate of lime. The accompanying table shows the mechanical analysis of a sample of this sand taken from the dunes along the lake shore. It is known as oolitic sand, because it resembles the petrified eggs of fish. Whether the spherules as such were formed in the process of separating from the water or whether they were formed by the action of the wind and water, from the broken fragments of lime-carbonate hardpan that occur in great quantity along the shore, was at first a matter of conjecture.

Mechanical analysis of Salt Lake sand.

Diameter.	Conventional name.	4355. Shores of G. S. L.
Millimeters.		
2 to 1	Fine gravel	0.62
1 to 0.5	Coarse sand	2.35
0.5 to .25	Medium sand	81.25
.25 to .1	Fine sand	15.32
.1 to .0001	Very fine sand—silt and clay	.51

Upon examining the different separations in the laboratory, however, it was found that the portion classed as fine gravel consisted of quite angular broken fragments of lime carbonate, the angles slightly rounded by erosion. The particles of the next grade—coarse sand—were much more rounded, although the larger ones were still quite angular, as could be seen by the naked eye. The third grade—medium sand—included over four-fifths of the sample, and in this all of the particles were well rounded, there being no angular ones. Under the microscope the most of these particles proved to be almost perfect spheres, while a smaller proportion of them were oblong or egg shaped. The

surfaces were quite smooth and highly polished. The fourth grade—fine sand—was similar to the third, but more of the particles were oblong and a few of them somewhat cylindrical, while the small percentage remaining in the class of very fine sand was chiefly angular particles of very fine sand and silt with just a trace of clay, the material being siliceous, not carbonate of lime. All of the particles, except those of the very fine sand, when treated with dilute hydrochloric acid give rise to a violent ebullition of carbon dioxid and soon disappear, leaving behind only a small flocculent precipitate, which, under the microscope, is shown to be clay particles with an occasional angular particle of silt. There seemed to be no nuclei to the lime carbonate particles, and all the evidence points to their formation by the breaking up of the thin pieces of lime-carbonate hardpan, which is quite abundant. These broken pieces, when sufficiently cubical, afterwards become rounded by the action of the water and the wind. Where the particles of lime-carbonate hardpan are flat they do not take on a rolling motion, and consequently do not become rounded. The particles are sufficiently soft to be easily crushed by pressure with a knife blade. It forms an insignificant area along the shore, either as dunes, which in some places reach 10 or 12 feet in height, or spread out on the beach and on the slightly elevated areas near the lake shore as a layer of from a few inches to several feet in depth. Whatever its mode of formation, the material evidently comes from the lake water, which has reached the saturation point in regard to carbonate of lime.

HARDPAN.

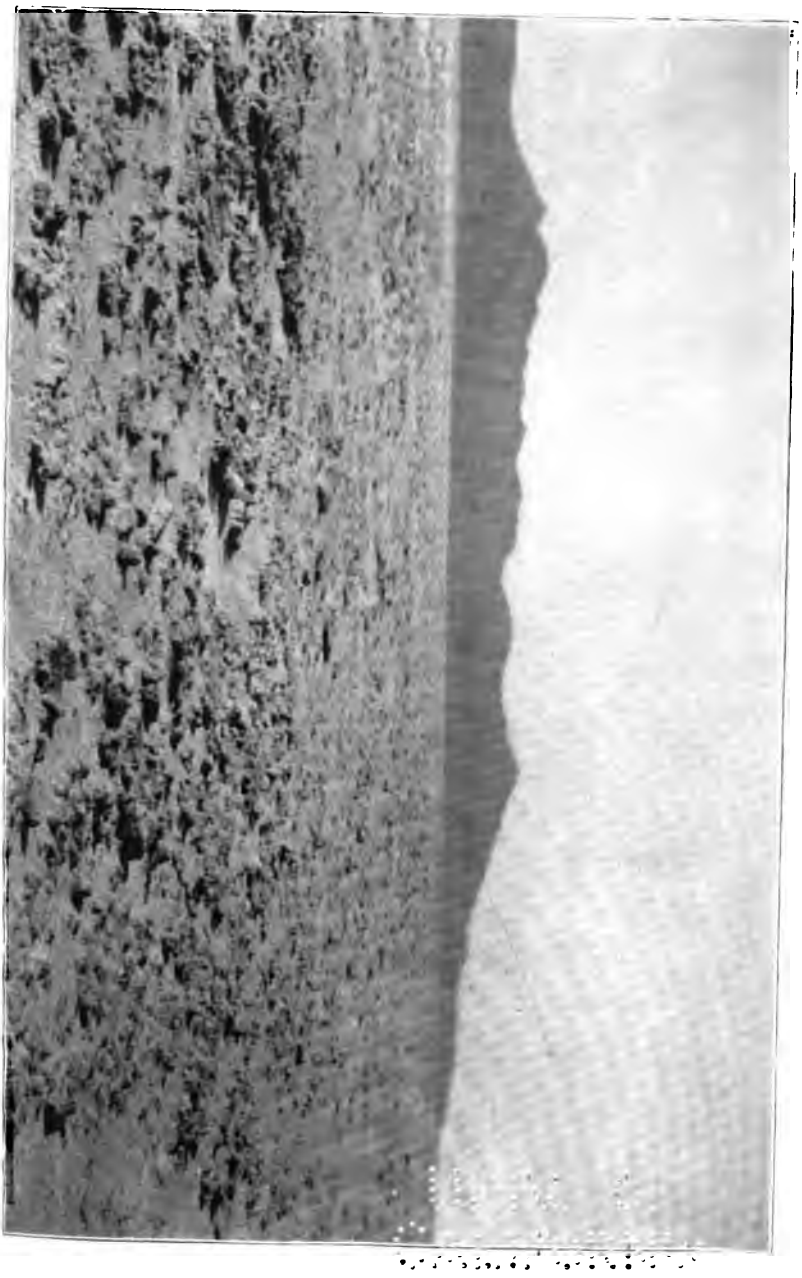
The sketch map of the valley on page 103 shows a number of small areas of hardpan on the level lands between Salt Lake City and Great Salt Lake. This formation occurs over an aggregate area of about 12 square miles. The hardpan usually occurs under the Jordan sandy loam. This material is encountered at from 12 to 30 inches below the surface and at an average depth of 18 inches. It is from 2 to 18 inches thick, and averages about 3 or 4 inches.

The texture of the hardpan is the same as the material immediately above and below it, but this layer has been cemented by lime carbonate. Under ordinary conditions it is quite pervious to water and to the roots of plants, but when dry it is quite hard and difficult to dig. When moistened with water and soaked for a while it softens considerably, but does not disintegrate to any appreciable extent. It effervesces freely with hydrochloric acid and falls apart into a sandy loam.

As would be expected, the subsoil immediately below the hardpan is quite moist throughout the season, while above it the soil is quite dry during the summer months. The soil above the hardpan is usually free from excessive quantities of alkali, while below the hardpan the salt content is very much greater.

On the shores of the Great Salt Lake very interesting observations

PLATE XIV.



FIRST STAGE OF THE FORMATION OF HARDPAN ON THE SHORES OF THE LAKE WITH DECOMPOSING ALGÆ BEING INCRUSTED WITH CARBONATE OF LIME.

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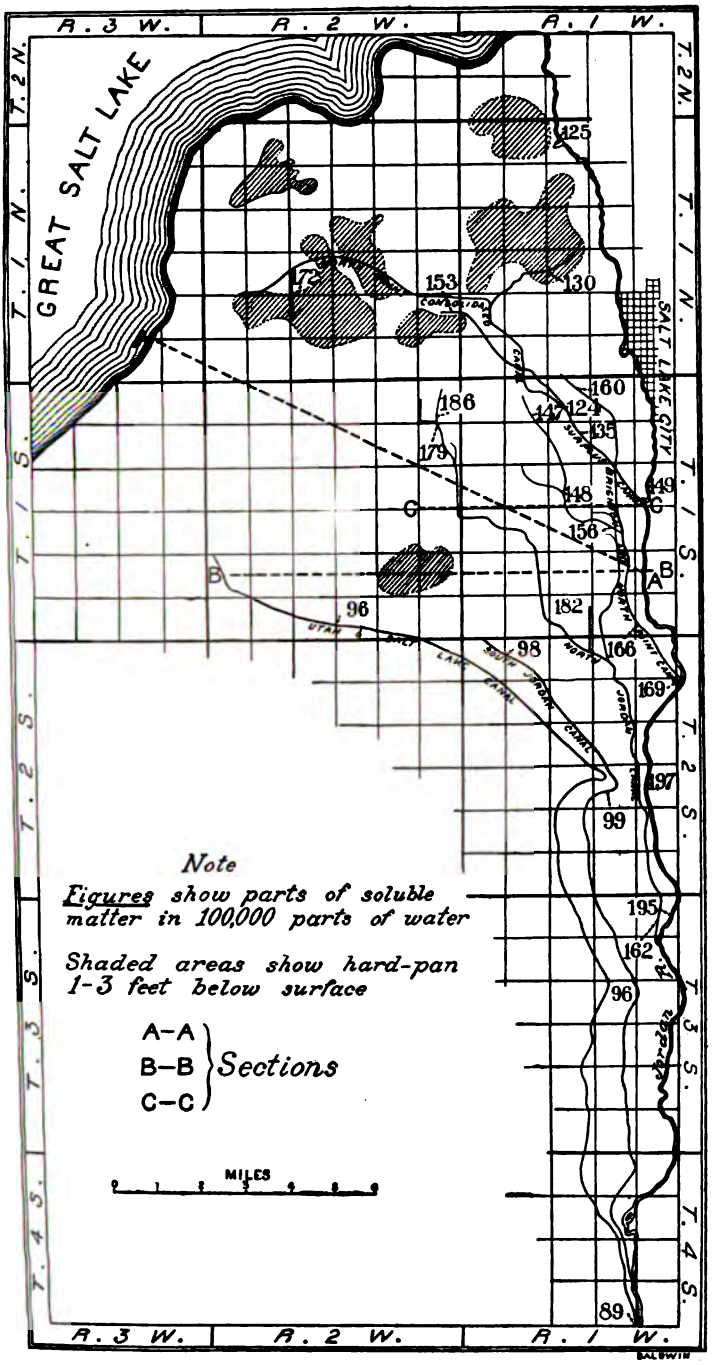


FIG. 10.—Sketch map of western part of Salt Lake Valley, showing canals, hardpan areas, and parts of salt in 100,000 parts of river and irrigation waters.

were made on hardpan forming on the surface and in all stages of formation. The preliminary stage was the washing up of algæ from the lake and of immense quantities of the salt shrimp, which lives in the lake waters, on to the beach. These gradually become crusted over with various salts, which, after repeated leaching, leave only the difficultly soluble lime carbonate. As the organic matter decomposes it is replaced with the lime carbonate, until the mass finally assumes the character of thin strata of broken limestone rock, nearly covering the surface over considerable areas.

Dr. Cameron has examined this material and has made the following interesting statements upon its probable mode of formation:

The samples collected on the shores of the lake by Mr. Gardner suggest some very interesting ideas as to the formation of hardpan. The samples all show the presence of calcium carbonate as such, more or less densely compacted, and there can be no doubt that this material is the cement holding together the other constituents which go to make up the hardpan. Calcium, in some form of combination, is present in the water of the Salt Lake. From an analysis made by Dr. J. E. Talmage in 1889 there appeared to be 0.084 per cent of calcium in the water, and it seems reasonable to suppose the amount is no less at the present time. The original source of the lime was probably in gypsum or carbonate of lime, and for our purpose it is a matter of indifference which it was. Gypsum (or the carbonate of lime either) is but slightly soluble in water free from other salts. But the presence of another salt markedly influences its solubility. If sodium chlorid be present, we shall have in the solution some sodium chlorid, some sodium ions, and some chlorin ions, thus:

$$\overset{+}{\mathrm{NaCl}}\quad \overset{+}{\mathrm{Na}}\quad \overset{-}{\mathrm{Cl}}$$

When the calcium sulphate is brought into contact with the solution we will get at once and in the same way calcium sulphate, calcium ions, and sulphions in the solution:

$$\mathrm{CaSO_4}\quad \overset{+}{\mathrm{Ca}}\quad \overset{-}{\mathrm{SO_4}}$$

But the sodium ions and the sulphions present will unite to a certain extent to form sodium sulphate. At once there is a tendency for the sodium chlorid to furnish more sodium ions and the calcium sulphate to furnish more sulphions to restore the equilibrium. In the same manner the calcium ions and the chlorin ions will unite to form the very soluble calcium chlorid in the solution with a corresponding tendency to the formation of further calcium and chlorin ions. While the gypsum is but sparingly soluble, all these other salts formed are quite soluble, and more and more of the gypsum will dissociate and go into solution until equilibrium be reached. If the sodium-chlorid solution be at all concentrated, it has been shown that the amount of gypsum soluble in it is astonishingly large. In this way it is easy to see how lime salts could be carried down to the lake. But just as the presence of a salt increases the solubility of another without a common ion, it decreases the solubility of the second salt if they both yield a common ion. Of all the possible salts which may form in a solution when in instable equilibrium as regard saturation, that salt which is the least soluble will, of course, be precipitated. Thus it is that the waters of the Salt Lake containing large amounts of soluble sulphates, practically saturated with respect to them in fact, contain but a very small amount of calcium.

Moreover, the water of Salt Lake has been shown in this laboratory to contain a small amount of carbonate, either calcium carbonate or, much more likely, sodium carbonate. This fact is not recorded in any of the published analyses of the water, so far as I know, and as a matter of fact this need not cause any surprise under the

acid, in the presence of moisture, would dissolve the lime carbonate with the formation of the bicarbonate, and the bicarbonate, in turn, would reprecipitate as the carbonate on drying. Still farther back from the water's edge was found another type of material, evidently representing a later stage in the genesis of hardpan. This material appears to be but very slightly affected by treatment with water. It is practically all soluble in moderately dilute hydrochloric acid, a small residue of light brown silt remaining. The cementing material proves to be almost entirely lime carbonate with, perhaps, some magnesium carbonate. It is quite dense and compact and noticeably free from the undecomposed organic matter in the specimens last described. It evidently represents a later product of the process of resolution in carbonated water, reprecipitation on drying, and may fairly be taken as the type of the final product in the genesis of a lime carbonate hardpan.

On the shore between the two deposits last described (or still farther back in the form of wind-blown dunes) are found great quantities of small, remarkably well-rounded spherules, whose composition appears to be either entirely calcium carbonate or calcium carbonate about a very small nucleus of sand or some siliceous mineral. Several hypotheses have been suggested as to the origin of this material, but so far none seems to have received much credence. I am inclined to think they originated from the forming hardpan on the shore, by the action of waves during rough weather, by splitting up of the parent material by frost, the result of wind action, or of all these agencies. Their rounded form is quite easily accounted for in two ways—as the result of rolling from the action of the water; by the etching due to the solvent effect of the water, it being a well demonstrated fact that in the absence of any special reason to the contrary the result of such action is always to round off the edges and produce a spherulitic form, thereby reducing the surface, and consequently the "active mass," to a minimum. The striking uniformity in the size of the particles may be taken as confirmatory evidence of the views just presented. Suppose the particles to have been originally of widely varying masses. At such times as they would have been under the influence of the water they would have been stirring about in a heavy, rather viscous brine, whose specific gravity would not be very far from that of the carbonate particles. Naturally the heavier particles would gradually accumulate at the bottom, the lighter ones at the top, and, as the turbulent actions ceased because the particles had practically the same shape and density, those of equal mass would have equal volume and would settle at the same time. The larger particles at the bottom might well be expected to gradually consolidate if left undisturbed for sufficient time, and some specimens collected by Mr. Gardner indicate that such action has taken place.

WATER SUPPLY.

The main water supply for the western part of the Salt Lake Valley is derived directly from the Utah Lake and delivered through the Jordan River, the distance between the lake and the Jordan Narrows, where the later canals are taken out, being about 6 or 7 miles.

Utah Lake is a large body of fresh water, having approximately 125 square miles of surface, but rather shallow. It is fed by rather short mountain streams, derived largely from melting snow. The water in these streams is of excellent quality and quite free from salts. The water of the lake itself contains rather more alkali, as the seepage from the surrounding lands—both irrigated and nonirrigated—sensibly affects the salt content. In the spring of 1899 Mr. Means found the salt content of Utah Lake to be about 50 parts in 100,000. In a shallow lake with such an extensive surface area the effect of evaporation during the summer must sensibly increase the concentration of the salts in the

cumstances. Its presence was discovered almost accidentally. Mr. Gardner had empted to test the water for alkalinity by adding phenolphthalein solution. No or whatever was apparent, but on throwing the contents of the vessel away and empting to rinse with distilled water a marked alkaline reaction was observed in e wash waters. Investigation showed the absence of any alkali in the distilled ter. An examination in this laboratory brought out the explanation of the enomena very clearly. There is sodium carbonate in the solution, and normally is would dissociate with the formation of sodium ions, which could be detected by e phenolphthalein. But the water contains so large an amount of salts with dium ions that the solution is saturated with respect to this ion, and, carbonates ing salts of a weak acid—that is, with a relatively small tendency to dissociate—e dissociation of the sodium carbonate is completely "driven back." Consequently ere is no dissociated sodium carbonate in the solution. On the addition of more ater, however, the concentration of the solution with respect to the sodium ion is creased, more sodium ions may be formed, and the sodium carbonate dissociates, hich fact is indicated by the phenolphthalein solution. This explanation was rified by repeated experiments with the water from the Salt Lake and with brines ntaining traces of sodium carbonate, prepared artificially. There is the further terest in these facts, that the absence of lime carbonates in the lake water has en the subject of much interest and speculation. The explanation is apparent om what has just been said. As the conditions are such that practically no disso-ated calcium sulphate or dissociated calcium carbonate can exist, the water will ly take up so much of these salts as is soluble without dissociation, somewhat less, fact, than if the other salts were not present in the water.

At the edge of the lake the spray carrying various salts in solution falls on unches of algæ and other organic matter, and, the water evaporating, the salts ntained are precipitated. Theoretically the first to separate should be the small mount of calcium carbonate present, and in a general way this is probably so, but is more or less mixed with the other salts. These other salts, being more soluble, re partially restored to the lake by the returning drip, by washing with rain water, tc., and the calcium carbonate already deposited will hasten the precipitation of ore calcium carbonate from successive washings of spray, and thus it will gradually ecumulate. In the specimens of the most recent formation collected by Mr. Gardner hese views are well exemplified. In water, either cold or hot, the material is artially disintegrated and dissolved, fragments of the algæ (green and well reserved) being obtainable from the residue, as well as small twigs and other rganic matter. The contents of the water solution appears to be in the main odium chlorid, though other salts might be found on a careful examination. The olution showed the presence of but little lime and did not effervesce noticeably on the addition of an acid. The residue insoluble in water proved to be nearly entirely carbonate of lime, a very small residue being left after treatment with dilute hydrochloric acid.

Farther back from the water's edge specimens were obtained, consisting of twigs, grasses, etc., dead organic matter, bound together with a material which proved on examination to be nearly all calcium carbonate, though there appeared to be quite a small amount of sodium chlorid and other salts present. On treatment with dilute hydrochloric acid, besides the dead organic matter there was a small residue of fine sand or silt left. This hardpan, while much harder and more compact than the one first described, is still sufficiently friable to be broken with the fingers, though with some difficulty, and is fairly porous. It can be regarded as representing a subsequent stage or later development of the first described specimens. The sodium chlorid and other water-soluble salts have been gradually washed out and returned to the lake. The calcium carbonate, by alternate redissolving and reprecipitation, has become more dense and compact. In this process the sodium chlorid may have been an important factor. It would seem quite probable that the dead organic matter might play a decided rôle in yielding by oxidation carbonic acid. This carbonic

sample taken from the Jordan River opposite Salt Lake City. The following table gives the result of these analyses:

Kind and amount of salt in Jordan River water as determined by Dr. Cameron.

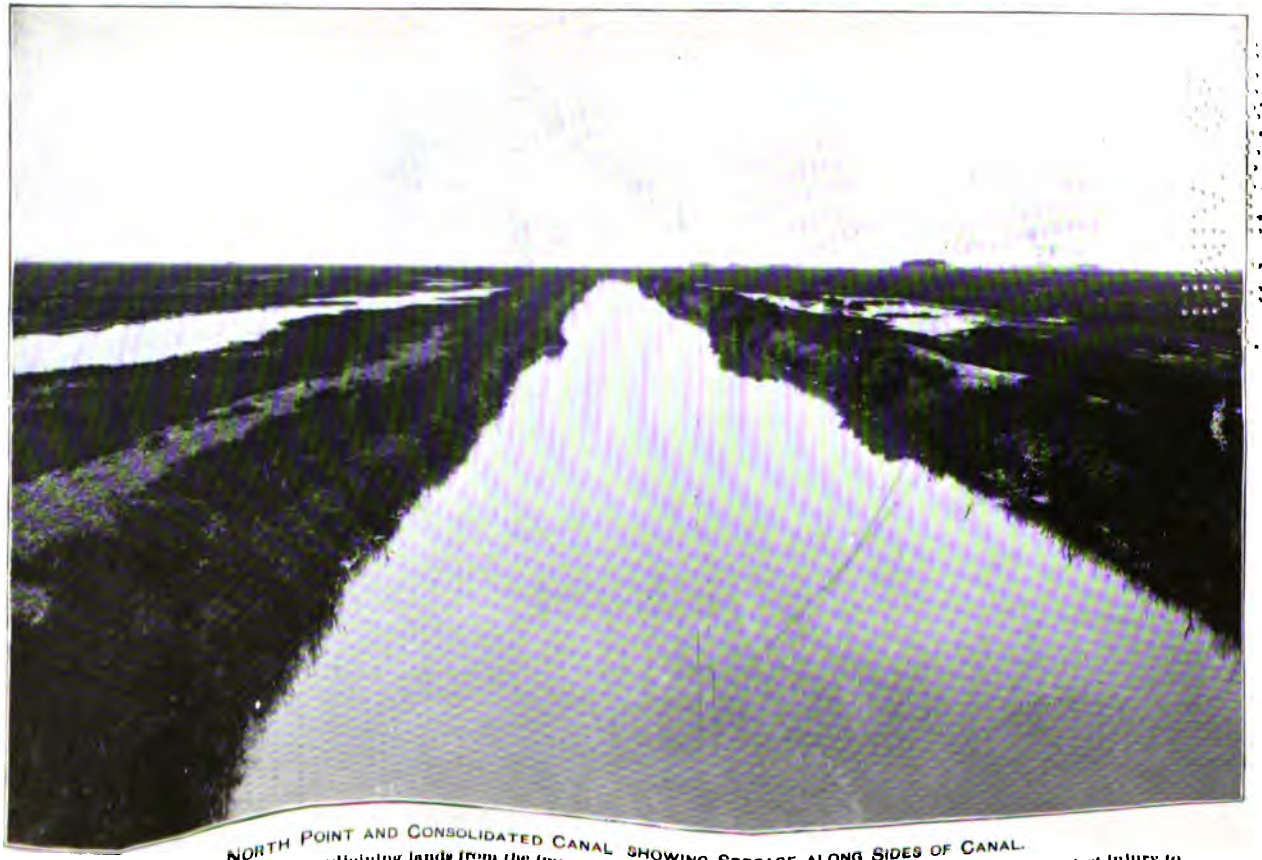
Kind of salt.	At intake of Utah and Salt Lake Canal, October 2.		At Salt Lake City, October 30.	
	Parts of salt in 100,000 parts of water.	Per cent of total salts present.	Parts of salt in 100,000 parts of water.	Per cent of total salts present.
Na_2CO_3	4.2	4.71	Trace.	
$CaSO_4$	23	25.78	38	34.6
Na_2SO_4	11	12.33	9.8	8.8
$MgCl_2$	5.4	6.06	5.4	4.8
NaCl	45.6	51.12	56.8	51.8
Total	89.2	100	109	100
Residue dried at 105° C	98		118.4	
Water of crystallization by difference	8.8		9.4	

The sketch map of the valley (page 103) gives the total salt content in parts per 100,000 as observed during the progress of the survey in different parts of the valley. It will be observed that there is considerable fluctuation in the salt content of the river between the Narrows and Salt Lake City. This is dependent on two causes. On the east side of the river there are a number of mountain streams which deliver a considerable volume of snow water to the Jordan River, thus improving the quality of the water by dilution. On the other hand, there is a large amount of seepage waters collected by the river from the lands on either side, and, as these waters are generally highly charged with alkali salts, the salt content of the river tends to increase. Without this explanation of the conditions prevailing it would seem strange to see a salt content at the Narrows of 89 parts per 100,000 and this increased, at a point about half way to Salt Lake City, to 197 parts; at the intake of the surplus canal it is 149 parts, while at a point only two or three miles from the mouth of the river the salt content is 126 parts per 100,000.

The increase below the Narrows is to be ascribed entirely to the seepage from the adjoining irrigated lands on either side, while the comparatively low salt content near the mouth is due to the large volume of purer mountain water delivered by the several creeks which empty into the Jordan River at Salt Lake City.

The sketch map shows the salt content of the water in the irrigation canals so far as observed during the course of the survey. These measurements cover a period of four months.

For plants growing with their roots immersed in water, i. e., grown by water culture and not in the soil, the limit of endurance is about 1 per cent, or 1,000 parts of salt per 100,000 parts of water. A soil containing 0.4 per cent of salt, saturated with pure distilled water, would have in the soil moisture a concentration of 1 per cent. As all of these soils contain more or less alkali, and as evaporation and consequent



NORTH POINT AND CONSOLIDATED CANAL SHOWING SEEPAGE ALONG SIDES OF CANAL.

damage has resulted to adjoining lands from the improper construction of canals. This is the source of the greatest injury to

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concentration set in immediately after the application of water to the land, it is unsafe to use water having a concentration greater than about 250 or 300 parts per 100,000 for irrigating the lands.

According to this standard it will be seen that all of the canals deliver water of a good quality for irrigation purposes, especially the higher canals. The Utah and Salt Lake Canal contains only about 95 parts of salt per 100,000 parts of water, the South Jordan Canal contains hardly more than this, while the North Jordan Canal contains nearly twice as much, but is still well within the limit of safety, at least so far as immediate effects are concerned. The limit of safety is dependent upon so many things—such as the salt content of the soil, the texture of the soil, the drainage, kind of crop, the stage and condition of cultivation, and the climatic conditions—that only very general figures can be given for such broad application.

APPLICATION OF WATER.

The three principal canals on the west side of the river with which we have to deal are the joint property of the owners of the irrigated land, each man having shares in proportion to the amount of land owned. Anyone not holding shares can rent water rights from those who own more shares than they have personal need of. The water is generally apportioned among the landowners in proportion to the stock they control. The exact amount of water used per acre in this district has not been determined; but the average for the State of Utah is estimated at about 1 second-foot for each 100 acres. There is generally an abundance of water in the canal; but when there is any deficiency all suffer alike in a reduced supply. The water is allowed to run continually throughout the season and the excess runs onto uncultivated or pasture land. There is believed to be more water used at times of abundant flow than is absolutely necessary. Furthermore, the highland canals run for a portion of the distance through very pervious gravelly loams. The seepage and waste waters from the canals account in great measure for the 10 square miles of good land which has already been ruined by seepage and alkali. It has been shown that the water is of good quality and the lands of the upper benches are naturally free from any great excess of alkali; but the continual seepage from the canals during the growing season for a great many years has transported a quantity of salt to the lower levels.

The necessity of careful construction of the canals, especially those on gravelly lands, and the desirability of preventing the waste water from flowing over the lower levels is sufficiently obvious without further comment.

The application of water on the low lands west of Salt Lake City, where there is a large amount of alkali in the lower depth, has been attended with very disastrous results to crops. The salt has quickly

risen to the surface and, even where the surface foot was originally free from alkali, the crops have been completely ruined in the course of two or three years.

A very serious feature of the prevailing practice is that the land upon which an excess of water is used, or the land adjacent to a leaking ditch, is often not injured for a while and may even be improved by the excess of seepage water; while the lands at the lower levels, perhaps under the second or third ditch, may receive the full effect of this pernicious practice or condition.

The advisability and even necessity of State legislation, to compel the ditch owners to guard against undue seepage and to prevent the property owners from using excessive amounts of water in irrigation, is sufficiently obvious to require no further comment at this place. Property owners whose lands are damaged by either of these means should be able to recover damages in civil suits.

UNDERGROUND WATER.

One of the maps accompanying this report gives the depth to standing water at the time of the survey. One of the three shades of green shows the area upon which standing water is found within 3 feet of the surface of the ground; another shows the area where the water is between 3 and 10 feet of the surface, and the third color shows where it is below 10 feet.

With standing water within 3 feet of the surface of the soil it is in no condition for any of our agricultural crops. Such areas must be drained in order to use the land for agricultural purposes. With water within 3 to 10 feet of the surface there is always more or less danger in the application of irrigation water. It is incumbent upon the owers of such land to watch the fluctuation of the underground water and to underdrain wherever necessary.

The texture of the soil, and especially the character of the subsoil, will largely determine the extent of the danger to be feared. The large areas south of Salt Lake City and the areas along the Jordan River with standing water within 3 feet of the surface are believed to be due entirely to seepage from the canals and from the irrigated lands above.

The underground water map shows, therefore, the areas which require immediate drainage to relieve the soil of surplus water. It is incumbent upon all those living within the areas colored medium and dark green to provide adequate drainage when the danger from underground water becomes imminent.

One of the pernicious effects of the accumulation of seepage waters is that the soil is made closer and more difficult to drain, therefore artificial drainage can be more economically and effectively applied before, rather than after, the collection of seepage waters near the surface.

LAST STAGE OF VEGETATION WITH ACCUMULATION OF ALKALI.

The last stage of vegetation is small annual saltbushes.

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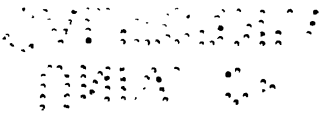
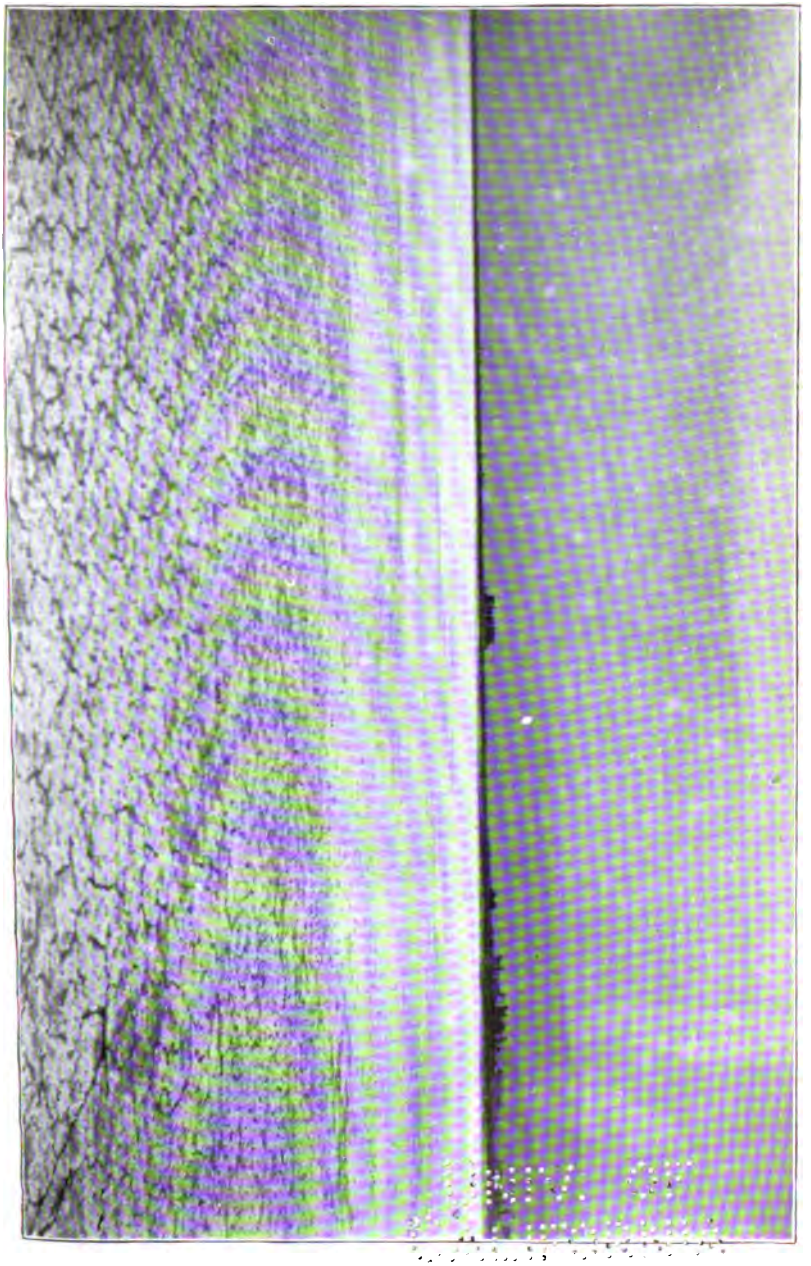
ALKALI FLAT TOO STRONG FOR SALTBUSHES.

Even saltbushes will not grow where the salt content in the top 6 feet of soil approaches 3 per cent.

ALKALI FLAT TOO STRONG FOR SALTBUSHES.

Even greasewood will not grow where the salt content in the top 6 feet of soil approaches 1 per cent.





ALKALI FLAT, FINAL STAGE, WITH NO VEGETATION.

These are indeed barren.

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ALKALI IN SOILS.

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Chemical composition of salts in crusts and soils as analyzed by Dr. Cameron.

No.	Locality.	Na_2CO_3.	$CaCl_2$.	$MgCl_2$.	$CaSO_4$.	$MgSO_4$.	Na_2SO_4.	NaCl.
4380	S. 1, T. 1 S., R. 1 W	.....	0.77	0.38	1.98	.....	.....	96.90
4381	3 miles northwest of S. L. C.	0.96	.....	.....	.79	0.25	31.15	66.84
4382	S. 32, T. 1 N., R. 1 W	9.28	.....	.....	1.06	.37	43.12	46.17
4383	S. 14, T. 3 S., R. 1 W	.....	.....	10.41	13.24	3.16	.....	73.18
4384	S. 24, T. 1 S., R. 2 W	Trace.	.....	.....	2.14	.12	11.97	85.94
4385	S. 2, T. 1 S., R. 1 W	Trace.	.....	.....	6.38	29.87	8.29	55.48
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4387	S. 29, T. 1 S., R. 1 W	.23	.....	.....	7.43	22.61	9.75	59.98
4388	Chambers, 2 miles east	.....	7.62	10.87	9.97	.....	.....	72.04
4389	S. 4, T. 1 S., R. 1 W	.30	.....	.....	.25	.71	49.43	49.30
4390	S. 1, T. 1 S., R. 2 W	.....	.....	4.77	9.32	2.64	.....	83.26
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The amount of alkali was determined by the electrical method in every foot down to at least 6 feet in depth. The alkali map represents what may be considered the average conditions, according to the judgment of the observer. If a boring showed a small amount of alkali in the surface foot and a large amount in the remaining depth the soil was classed as unfit for cultivation, as it would require but one or two applications of water to bring an excessive amount of salt to the surface.

Attention is called to the very large accumulation (over 3 per cent) of soluble salt in certain areas in the land west of Salt Lake City. There is a general agreement between the alkali map and the soil map, as would be expected, but this is influenced to a considerable extent by the topography of the country. The heavy clay soils and the land having this material within a short distance of the surface have generally the largest accumulation of alkali, on account of the imperfect drainage. The soil of the uplands is naturally free from excessive amounts of alkali, while the level area between Salt Lake City and the Great Salt Lake contains excessive amounts of salt. This latter fact is undoubtedly due to the influence of the Great Salt Lake, which, within comparatively recent years, covered much of this area. There are no antidotes for this kind of alkali, with the exception of the sodium carbonate, and adequate artificial drainage is the only practical means of reclaiming the land and providing against further disaster. The possibilities of reclaiming the level tract west of Salt Lake City will be described under a subsequent head.

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It is clearly apparent, from the investigations in the Salt Lake Valley, that our different staple crops can stand different amounts of alkali. These limits have been shown on the alkali map by different colors.

A number of factors enter into the question of the limit of endurance of plants for alkali. With the same amount of alkali plants will suffer less in the heavier soils than in the sandy. They will stand more alkali with thorough cultivation, and they will often stand a considerable amount of alkali if they are started under favorable conditions. In some districts of California sugar beets do well on soils containing a large amount of alkali. They are planted in the spring when the ground is wet either by rains or by previous irrigations, which carry the alkali into depths of the soil. When the soil dries out the alkali is brought to the surface and is left above the area of the active roots. It is a common practice in some localities to irrigate heavily just before planting in order to accomplish this very purpose. Obviously this method would not be successful when the soil to a considerable depth contains an excessive amount of salt.

Along the ridges and draws in the level west of Salt Lake City, where good drainage is secured, crops are frequently cultivated with a moderate degree of success when the land has a salt content higher than would be permissible were the drainage less complete. In a considerable percentage of this area the surface is comparatively free from alkali. Many attempts have been made to bring such land under irrigation, but the results have been disastrous after one or two years. In the upland soils of this locality the excessive accumulation of alkali, in land which was formerly free from salt, is almost invariably preceded by an accumulation of seepage water. The treatment for alkali, therefore, in soils previously free from salt, is almost always accompanied by the problem of getting rid of the seepage waters.

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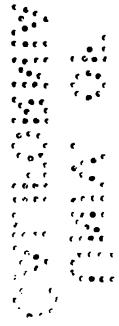
The corrosive sodium carbonate is present in considerable amounts in the soils west of Salt Lake City. The best antidote for this, as Hilgard has pointed out, is the application of calcium sulphate, which, under proper conditions of drainage and aeration, converts the sodium carbonate into sodium sulphate or white alkali. On every area in which there is an excess of sodium carbonate there is also an excess of white alkali. It would be a waste of money, therefore, to apply calcium

INSTRUMENTS FOR SALT DETERMINATION ON RIGHT OF AUGER, AND FOR SODIUM CARBONATE AND CHLORID ON LEFT OF AUGER.

Small and convenient outfit for determining the soil conditions.



ncentration set in immediately after the application of water to the ıd, it is unsafe to use water having a concentration greater than out 250 or 300 parts per 100,000 for irrigating the lands.

According to this standard it will be seen that all of the canals de- er water of a good quality for irrigation purposes, especially the ;her canals. The Utah and Salt Lake Canal contains only about 95 rts of salt per 100,000 parts of water, the South Jordan Canal con- ns hardly more than this, while the North Jordan Canal contains arly twice as much, but is still well within the limit of safety, at least far as immediate effects are concerned. The limit of safety is depend- t upon so many things—such as the salt content of the soil, the tex- :e of the soil, the drainage, kind of crop, the stage and condition of ltivation, and the climatic conditions—that only very general figures a be given for such broad application.

APPLICATION OF WATER.

The three principal canals on the west side of the river with which) have to deal are the joint property of the owners of the irrigated ıd, each man having shares in proportion to the amount of land owned. ıyone not holding shares can rent water rights from those who own ore shares than they have personal need of. The water is generally portioned among the landowners in proportion to the stock they ntrol. The exact amount of water used per acre in this district has ıt been determined; but the average for the State of Utah is esti- ated at about 1 second-foot for each 100 acres. There is generally ı abundance of water in the canal; but when there is any deficiency l suffer alike in a reduced supply. The water is allowed to run con- nually throughout the season and the excess runs onto uncultivated : pasture land. There is believed to be more water used at times of)undant flow than is absolutely necessary. Furthermore, the high- nd canals run for a portion of the distance through very pervious ravelly loams. The seepage and waste waters from the canals account ı great measure for the 10 square miles of good land which has already een ruined by seepage and alkali. It has been shown that the water ı of good quality and the lands of the upper benches are naturally ee from any great excess of alkali; but the continual seepage from he canals during the growing season for a great many years has ransported a quantity of salt to the lower levels.

The necessity of careful construction of the canals, especially those n gravelly lands, and the desirability of preventing the waste water rom flowing over the lower levels is sufficiently obvious without further)mment.

The application of water on the low lands west of Salt Lake City, where there is a large amount of alkali in the lower depth, has been ıttended with very disastrous results to crops. The salt has quickly

risen to the surface and, even where the surface foot was original free from alkali, the crops have been completely ruined in the cour of two or three years.

A very serious feature of the prevailing practice is that the land up which an excess of water is used, or the land adjacent to a leaki ditch, is often not injured for a while and may even be improved b the excess of seepage water; while the lands at the lower levels, perha under the second or third ditch, may receive the full effect of th pernicious practice or condition.

The advisability and even necessity of State legislation, to comp the ditch owners to guard against undue seepage and to prevent th property owners from using excessive amounts of water in irrigatio is sufficiently obvious to require no further comment at this plac Property owners whose lands are damaged by either of these mean should be able to recover damages in civil suits.

UNDERGROUND WATER.

One of the maps accompanying this report gives the depth to standing water at the time of the survey. One of the three shades of green shows the area upon which standing water is found within 3 feet of the surface of the ground; another shows the area where the water is between 3 and 10 feet of the surface, and the third color shows where it is below 10 feet.

With standing water within 3 feet of the surface of the soil it is in no condition for any of our agricultural crops. Such areas must be drained in order to use the land for agricultural purposes. With water within 3 to 10 feet of the surface there is always more or less danger in the application of irrigation water. It is incumbent upon the owers of such land to watch the fluctuation of the underground water and to underdrain wherever necessary.

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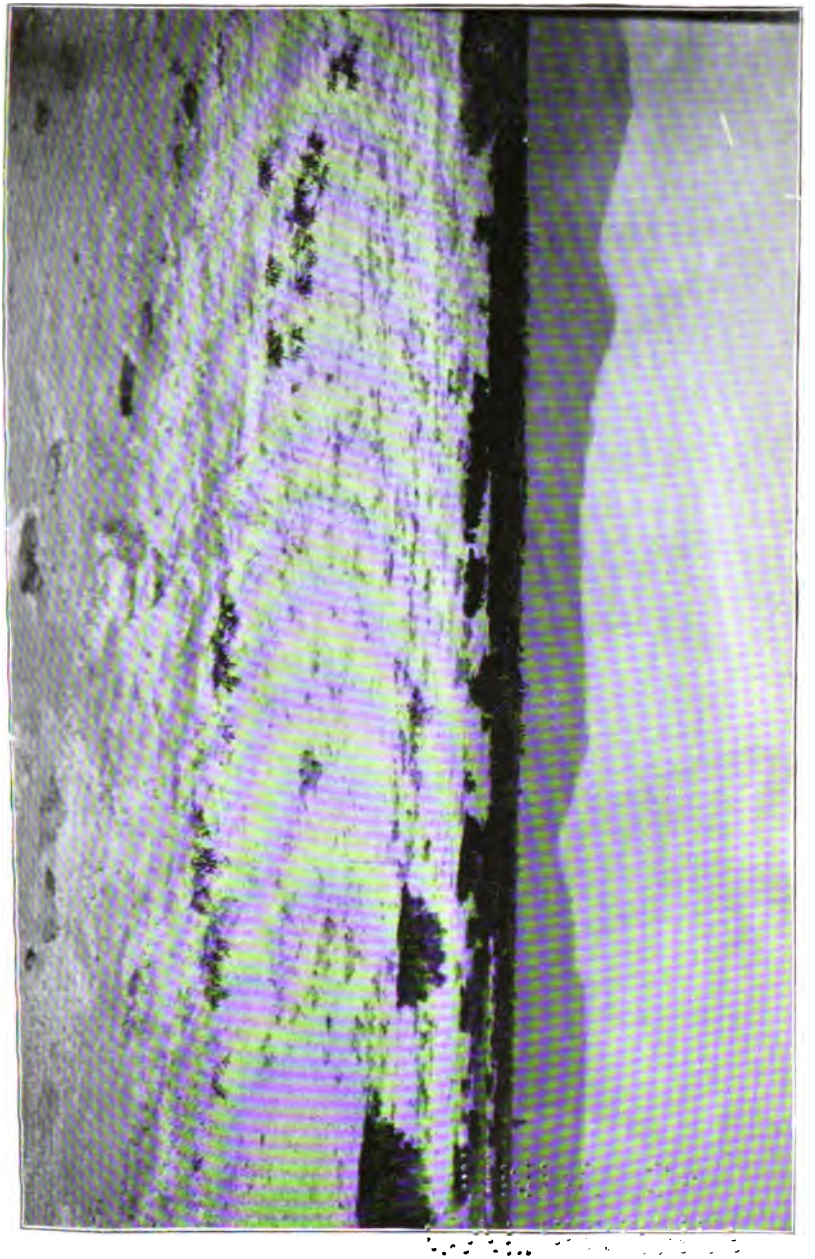
WE WANT
AUGUSTUS



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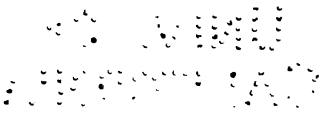

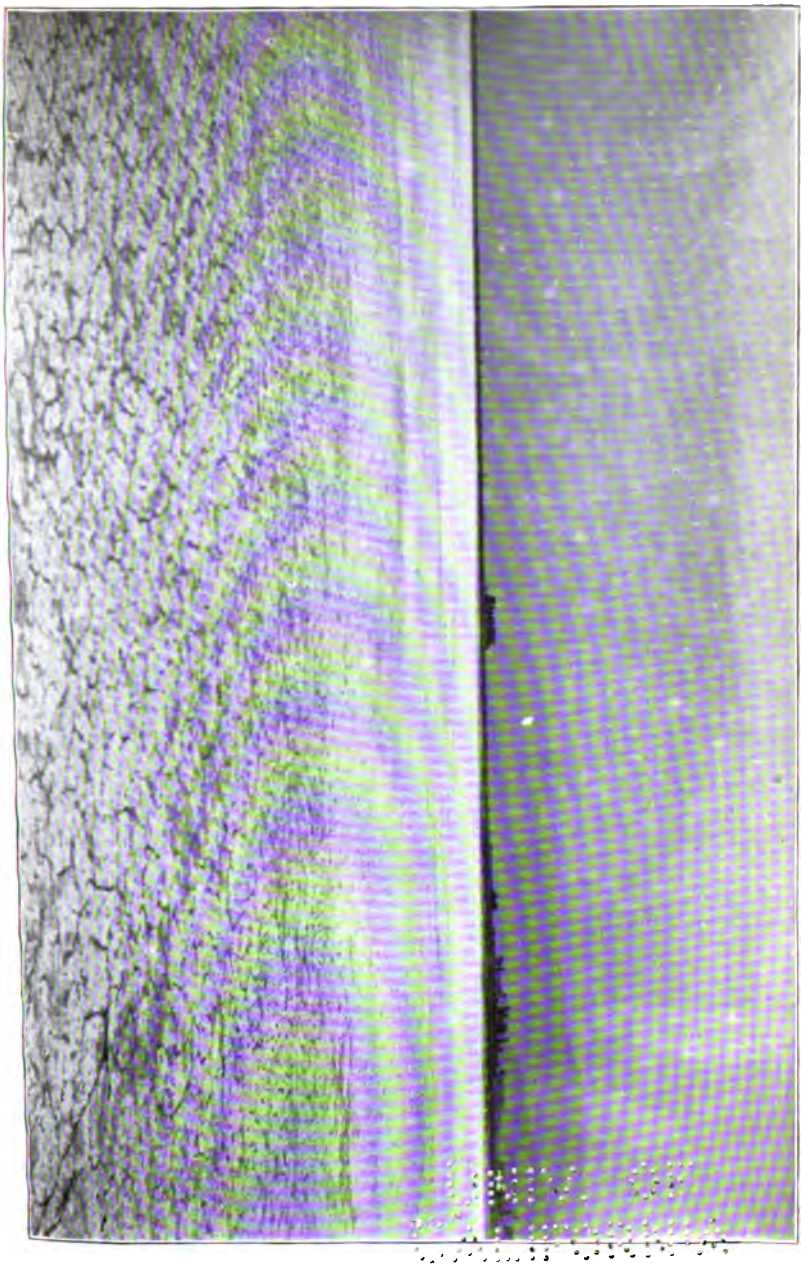

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Plowed area indicated by arrow.

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...instrument outfit for determining the soil condition.

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he limit of endurance of plants for sodium carbonate is assumed e that which Hilgard determines for the California soils, namely, er cent. The lower limit of what may be called the danger line been placed at one-half this amount.

ttention is called to the very large amount (over 0.25 per cent) of um carbonate in the soils of certain areas. The surface crusts sionally contain as much as 10 per cent of sodium carbonate. te often there are large accumulations of calcium chlorid, which in instance has amounted to about 40 per cent of the total salts ent. There is also frequently an appreciable amount of strontium rid in the crust, and the suggestion is made that some of the osits may be sufficiently rich in one or more of these three salts to rant commercial development. No special attention, however, was d to this particular feature.

UNDERDRAINAGE AND THE RECLAMATION OF WASTE LAND.

ttention has already been called to the necessity of underdrainage protection against injury from seepage waters and alkali and for reclamation of injured lands. Irrigated lands in the Salt Lake lley are worth at least from $60 to $100 per acre. Lands immedi-ly adjacent to Salt Lake City, especially if held as suburban prop-y and if free from alkali, would be worth much more than this. ere is plenty of good tile clay in the vicinity of Salt Lake City, and e could be manufactured for the farmer at a reasonable cost. It is imated that it would cost from $10 to $20 an acre to underdrain ese lands which, under the present conditions, have a merely nomi-l value.

Lands in New York, Ohio, and Illinois, worth from $50 to $75 per re, have been very extensively underdrained in order to increase their oductiveness, to hasten the maturity of the crops, and to insure the ops from injury by drought. It would certainly be a reasonable prop-sition to protect these valuable lands and to reclaim in the same way hat would be valuable land. Money so invested is in the nature of n insurance against loss of crops from seepage waters and alkali.

During the course of this investigation particular attention was iven to the possibility of reclaiming the vast tract of 125 square miles etween Salt Lake City and the Great Salt Lake. The levels of the ailroad surveys and of the canal companies were freely consulted. At Salt Lake City the level of the Jordan River is about 20 feet above he level of the water in the Great Salt Lake. The distance across is bout 14 miles. There is a slight ridge, however, running a little west of north, about a third of the way across from Salt Lake City. From the crest of this ridge to the Great Salt Lake there is a uniform fall of approximately 3 feet to the mile. This would be ample for the main

drainage canals, as the irrigating canals have only about one half t fall. Furthermore, there are many draws, already 4 to 8 feet de extending like fingers through this area, which with little additio work could be made to answer for a considerable part of the drain system.

On account of the impervious nature of the Jordan clay, the gr salt content, and the low elevation, it would not be advisable to atte drainage over this class of land at the present time. Subtracting t area, estimated at 35 square miles, from the 125 square miles, the va of the remaining lands, if thoroughly drained, would be about $3,0 000. At present they have merely a nominal value.

Any large drainage system of this kind can be established m efficiently and economically by a company than by individual effo For an enterprise of such magnitude—so nearly affecting the welf of a large number of people—the State or county could well use credit in assisting the undertaking. This is commonly done in simi enterprises in other localities. There seems to be little doubt of t feasibility of reclaiming this land from the engineering point of vi and, with the abundant supply of water, there is still less doubt of efficiency of the system when once introduced. The possibilities sho appeal to the commercial spirit of the people and induce capital undertake this very desirable enterprise.

ACKNOWLEDGMENT.

The authors wish to acknowledge their indebtedness to Col. C. Stevenson, secretary of the Utah State Irrigation Society, and to Messr George A. Lowe, T. J. Almy, E. E. Jerome, and others for their assi ance and interest in the investigations. Also to Mr. Wilks, coun surveyor, and Mr. Kelsey, city engineer, for base maps and data relati to water measurements and levels for various places in Salt Lake Count Officials of the Oregon Short Line Railroad kindly furnished transpo tation over all of their lines within the State. which was of materi assistance.

RECONNOISSANCE IN SANPETE, CACHE, AND UTAH COUNTIES, UTAH.

By THOS. H. MEANS.

GEOGRAPHY AND TOPOGRAPHY.

A portion of July, 1899, was spent in a rapid survey of the alkali soils of Utah, Sanpete, and Cache counties in Utah, with the following results, briefly given. The conditions in these three districts are in general very similar, yet each district differs from the others in certain respects.

Utah County lies directly around the fresh-water lake that bears the same name, and all of its irrigated land is on what was, at a previous epoch, the bed of Lake Bonneville. The soils are the sediments of this ancient lake, more recently modified by the inflowing streams and by weathering.

The irrigation water supply is obtained from the mountain streams, the principal ones being American Fork, Provo River, and Spanish Fork. The source of the water supply for these streams, during the irrigation season, is chiefly the melting snow on the high mountains of the Wasatch Range, and the water is therefore of excellent quality. It contains about 15 parts of soluble matter per 100,000.

The irrigation systems consist of a series of canals and ditches owned and operated by the farmers. Parts of the valley have been under cultivation for about forty years. When the valley was first settled the strip of land immediately around Utah Lake was wet and swampy. By irrigating the upland the wet land has greatly increased in area, this increased wet area becoming less valuable, although still furnishing desirable grazing. The principal damage is from seepage waters, but where the soil is heavy, salts have accumulated at the surface in sufficient quantities to seriously damage the meadows.

Moderate amounts of salts are everywhere present in the soil and through the agency of irrigation and seepage waters they are concentrated within small areas. An examination of the seepage waters from the benches showed comparatively small amounts of salts present, but these mildly charged solutions are often much concentrated by evaporation and give rise to large accumulations of salts in the soil.

Sanpete County is located in the central part of Utah and its farming lands lie in the valleys of the San Pitch and Sevier Rivers. The land lies at a greater altitude than the ancient Lake Bonneville, and the soil formation is therefore somewhat different from that of the preceding county. The valleys are more level and slope more gradually to the mountains than in the lake basin proper.

The irrigation water supply is derived from several sources. Around and above Manti the water is taken directly from the mountain canyons and is good. Ten miles above Gunnison the San Pitch is dammed, thus forming a storage reservoir which supplies water farther down the valley, around the junction of the San Pitch and the Sevier.

The water of this reservoir, at the time it was examined, carried between 50 and 100 parts of soluble matter per 100,000. The lands to the south of Gunnison receive their water supply from the Sevier River, as do also the lands around Richfield. The water of the Sevier River during a part of the year is diverted at a point above Gunnison. Gradually a portion of it returns to the river as seepage and at Fayette it is again all taken out for irrigation. Still farther down, at Deseret, the stream is drained for the third time.

The water as first taken from the river is good; but the second time it is contaminated by the seepage from the Gunnison district. The water in the Fayette Canal contained, in July, 1894, 250 parts of soluble matter per 100,000; while in the Sevier River, just below Fayette, it contained over 300 parts. At Deseret it was probably still worse. The application of water containing more than 300 parts of soluble matter per 100,000 is attended with great risk unless precautions are taken to prevent concentration within the soil.

Cache County lies in the north-central part of Utah, the farming lands receiving water directly from the tributaries of the Bear River. The irrigation water supply is taken from the mountain streams and is of excellent quality.

SOILS.

The soils of the three districts mentioned above are so similar that they may be conveniently discussed under one head. The farming lands of both Cache and Utah counties are all in the Bonneville beds, and the soils were formed from sediments deposited from the ancient lake, and have, since its subsidence, been considerably modified by inflowing streams and by weathering. The soils of Sanpete County lie above the level of the ancient lake and were formed by material brought down from the adjacent mountains. They are very similar, however, to those of the two preceding counties.

In each of the districts the soils in several parts vary from light sand and small gravel, through all grades, to the heaviest and most tenacious clays. The upper benches of the deltas around the mouths of the canyons, and also the shore benches of Lake Bonneville, are covered with gravelly soils, grading down into coarse gravel. These soils are

ll underdrained and therefore free from salts, but owing to the thinss of the soil proper, and to the difficulty of applying water and cul-ating the soil, they are but little farmed. The soils of the lower nches contain less gravel, but are sandy and of light texture.

Upon the lower and more level parts of these valleys there are great riations in the soils. In those parts farthest from the inflowing eams, where the water movement is slow, the soils are heavy and en contain as high as 50 per cent of clay. As we approach the trance of streams, where the water movement becomes more and re rapid, the soils are noticeably lighter, grading through loam, ndy loam, and at the mouths of streams becoming sandy or gravelly. igation on the loose soils results in the transportation of considera-salt to the lower and heavier soils, where it is most difficult to get l of. Around Utah Lake there is considerable of this heavy land at has been more or less damaged by seepage and alkali from the nds above, and in Cache Valley there is a large area of wet clay nd which is used for meadow and grazing. Though of considerable lue in this way, the value could be much enhanced by drainage and ltivation.

ALKALI IN SOILS.

In Utah and Cache counties both the black and white forms of kali are present. Originally moderate amounts of alkali were prob-ly everywhere present in the soil, and through the agency of irriga-on and seepage waters a part of these salts has been transported nd concentrated in local spots.

The three following analyses, by Dr. Cameron, show the approximate mposition of alkali from Utah County:

	4160. Crust from shore of Utah Lake.	4161. Black crust, 2 miles N. W. of Provo.	4162. White crust, 3 miles N. W. of Provo.
$_{80_4}$	3.96		
$_{2}SO_4$	33.68		6.32
$_{2}SO_4$	10.02		65.73
$_{aCl}$	52.34	79.09	26.69
$_{2}CO_3$	0.00	20.91	1.26

The crust, No. 4160, was collected from near the shore of Utah Lake pon a bar surrounded by swamps. The water of the lake contains ypsum in solution. Gypsum acts as a chemical correction for the lack alkali, changing it over into sodium sulphate. Here the process as been complete; all of the sodium carbonate has disappeared.

In sample No. 4162 the per cent of sodium carbonate is so small as ot to show black in the crust as collected.

The black alkali, where present, is in spots and small areas and its reclamation with gypsum will prove an easy matter.

In Cache County the black alkali is limited to spots and tracts in the west-central part of the valley and is always associated with the white alkali. Gypsum is found in some of the heavier soils and serves a valuable office in ameliorating the severity of the black alkali.

The following analyses, by Dr. Cameron, show the composition of the salts under the two typical conditions:

	4172. Tule swamp crust, 5 miles SW. of Logan.	4174. Black crust, 3 miles SW. of Logan.
$CaSO_4$	2.07	
$MgSO_4$	39.11	
Na_2SO_4	36.38	46.38
NaCl	22.44	41.65
Na_2CO_3		12.58

In Sanpete County the alkali, so far as examined, was all white. The presence of gypsum in nearly all of the soils and in the irrigation waters would lead one to expect this.

The following analyses, by Dr. Cameron, illustrate the variation in the composition of the salts:

	4165. Red crust, 5 miles S. of Gunnison.	4166. White crust, 5 miles S. of Gunnison.	4170. Yellow crust from kaolin mine, 2 miles SE. of Gunnison.	4171. White crust under loose soil from hillside, 3 miles SE. of Gunnison.
$CaSO_4$	1.27	3.14	3	3.51
$NaSO_4$	73.40	89.03		95.69
$MgSO_4$			7.18	
$MgCl_2$			4.47	
NaCl	25.33	7.83	85.33	0.80

Samples 4165 and 4166 represent the alkali as found in the soil, while 4170 and 4171 were collected to represent some of the possible sources of the salts. In each of these samples gypsum is present in sufficient quantity to prevent the formation of black alkali in a well-aerated soil. In the foothills south of Gunnison rock salt is mined; the streams cutting through these hills are likely to become contaminated with this salt and carry it to the irrigated lands below, much to their detriment. No actual exposure of the salt is at present visible along the stream beds, but the underground flows and heavy floods, no doubt, carry much of this salt valleyward.

One of the highland canals, running along the base of these hills, leaked in a gravelly place and the resulting seepage at the foot of the hill was heavily charged with salt and formed a heavy crust over the surface of the ground. There is much apprehension that this upland canal, through its seepage, will wash alkali down to the lower, heavier lands and damage them. In order to prevent this the canal should be protected from leakage and great care exercised in the use of water on

light soils of the upper slopes. Wherever the level of standing
ar begins to rise and threatens to come near the surface the land
uld be underdrained. Protection from seepage is sometimes afforded
seepage ditch, providing the ditch is dug along an impervious layer
ch naturally rises, and therefore raises the seepage waters. If no
ı layer is present a seepage ditch would afford little protection.
There irrigation waters carry a high percentage of salts, or where the
is naturally salty, surface flooding is thought to be better than
ow irrigation. By furrow irrigation a crust of salt accumulates
g the tops of the furrows to such an extent that in time it may
vent the growth of plants, except in the bottom of the furrows where
water washes down the accumulation of salt from the previous
gation. By flooding, the salts over the entire surface are washed
n and, if drainage be good, they will pass off through the under-
und drainage, but if the drainage be poor they will return to the
face. To prevent as far as possible the return of salts to the surface,
growth of shading crops or thorough surface cultivation should be
orted to.
here are some plants more resistant to alkali than others, and by the
ivation of these, alkali lands may be at times utilized. Such plants
the Australian saltbush, sugar beets, sorghum, and sweet clover are
thy of trial.
t is found that sweet clover will grow successfully with as much as
er cent of salt in the soil. It is a biennial, and therefore easily
moved from the land. It is a deep-rooted legume, and consequently
ens the soil and supplies nitrogen. Its blossoms furnish excellent
food and the leaves and stems are eaten by cattle to some extent.
serves the twofold purpose of improving the land and furnishing
age.

SUMMARY.

The discussion of the conditions in the three counties included in the
onnoissance shows, in all the cases cited, that the presence of alkali
ts within the soils is due to defective natural drainage. The obvious
edy is artificial drainage. Where farming is as intensive as it is in
ne parts of Utah the first step in the natural reclamation of the land,
er application of water, should be drainage. This feature of the irri-
tion question has been neglected and the result has been the damag-
of valuable land. The method which should now be adopted for
reclamation of the lands abandoned on account of seepage waters
d alkali is the same method which, if originally applied, would have
sured against such damage—that is, underdrainage. Tile drains
er the most effective and, in the end, the cheapest method of draining
e soil.
The application of gypsum or land plaster can be recommended for
e black alkali soils. The effect of the gypsum on such soils is two-
ld: First, the gypsum improves the physical condition of these heavy
nds, that is to say, it renders the soil more loamy in character and

easier to cultivate and drain; and, second, it neutralizes the bla alkali, turning it into the white salt. Gypsum is not a chemical an dote for the white alkali, and its application to white alkali lands can of little value, except in so far as the gypsum improves the physi properties of the soil.

The growth of deep-rooted crops tends to loosen the soil and to p mit the free downward movement of the water. This effect, togeth with the shading of the ground in order to prevent evaporation and t consequent formation of alkali, is well illustrated in the growth alfalfa.

A RECONNOISSANCE IN THE CACHE A LA POUDRE VALLEY, COLORADO.

By THOS. H. MEANS.

SOILS AND ALKALI.

The Cache a la Poudre Valley, or the Greeley country, as it is sometimes called, is one of the oldest as it is one of the most prosperous irrigation districts of the West.

One month was spent in a reconnoissance of this valley in the summer of 1899, and as the conditions there are unique in a way the results of the investigations may be of more than mere local interest.

The Cache a la Poudre Valley, or at least that part of it which lies east of the foothills of the Rocky Mountains, is cut from a series of nearly horizontal strata of cretaceous rocks. That portion of these strata which is exposed in the irrigated parts of the valley is largely sandstone or sandy shale, though at some places a bed of heavy blue shale is exposed. From these shales and sandstones the soils of the valley are formed, modified in a measure by the mixture of materials brought down from the mountains by the streams. The farming lands are situated on a more or less perfect system of terraces extending back from the stream and merging indefinitely into the upland, which consists of hills rounded by erosion. The lateral valleys, which extend back from the main Poudre Valley, are the result of flood erosion, no water flowing through any of them before irrigation was practiced except during times of heavy rains.

The soils of the bottom lands are generally sandy or gravelly, with coarse, gravelly subsoils. Such soils, where well drained, furnish excellent truck lands; but the greater part of this low land is wet from the seepage from the upper irrigated lands, and at present is used for pasturage and hay crops.

The second and third bottoms consist of heavier soils, becoming in some places a heavy clay. This clay land, on account of its impervious nature, acts as an obstruction to the flow of seepage waters from the uplands, and is in consequence often wet or alkaline. This type of land abuts directly against the upland soils, and extends around the mouths of the draws and lateral valleys. The same type

of heavy soil is found in the bottoms of the draws, where the natural moisture has collected the fine particles of soil from the hillsides and promoted the disintegration of the large grains.

The greater part of the farming lands of the valley lies upon the rounded hills of the uplands. The soil on these hills is a sandy loam in nearly all cases, varying slightly in texture. Immediately north of Greeley it contains about 7 per cent of clay, while north of New Windsor it contains 12 per cent, and around Fort Collins the soils are as a rule still heavier.

Many inclosed basins are found throughout the country, in the bottoms of which the soil is heavy and impervious. In these natural basins the water collects after each rain, and when they are irrigated the waste water collects in the lowest parts, forming swamps. The bottom lands were the first to be irrigated, and as the country became more thickly settled new canals were built covering the higher lands. In this way the irrigated land has extended back from the river to a distance in some places of more than 10 miles. The construction of one canal above another in this way has opened a wide field for inquiry into the possibilities of damage from seepage water, and in the present investigation special attention was given to the damage already done and to the possible remedies for this damage.

Since the time allotted to the field work was too short to warrant a complete study of the district, two townships were selected, comprising a strip of land from the Poudre to the desert land above the uppermost canal, the Larimer County Canal. This section was studied in detail, and the areas of wet or alkali soil were outlined in the field on a map. In this way a definite idea was obtained of the amount of wet land which at present exists, and the best means for removing this excess of water were considered.

It was found that the amount of wet land under the Larimer County Canal is small and confined to the bottoms of draws and land immediately adjoining the canal. The whole of the area under the Larimer County Canal is not farmed at present, but when all the land is farmed this area of wet land will be likely to increase. The seepage water, however, seems to originate in the losses from the canals and constantly running laterals rather than in seepage from the irrigated fields.

Professor Carpenter, of the Colorado Experiment Station, has investigated the question of the origin of the seepage waters, and, in his opinion, the greater part comes from the canals and laterals.

The material through which the canals run is largely loose in character, and the water is clear, carrying very little material which would clog the interstitial spaces of the soil. There can be no question, however, but that over irrigation, through ignorance or neglect, is also the cause of much seepage. The effect of over irrigation is very noticeable in some districts, and the careless use of water can not be too strongly condemned. It not only injures the land to which it is applied, but it

also largely increases the seepage water to the destruction of lower lands.

Under the Larimer and Weld Canal the amount of actual damage is greater than under the Larimer County Canal. The lands have been under irrigation longer and the subsoil has had more opportunity to fill up; besides, the amount of land irrigated is larger. This land also receives the seepage from the lands under the Larimer County Canal.

Under No. 2 canal the amount of wet land is still larger than under either of the canals above mentioned. It receives the seepage from all the land above, as well as the seepage from several reservoirs situated at a higher elevation. The soils under No. 2 canal are heavier than the upland soils, the land is more level, and the natural drainage is poorer. In the district mapped several large areas of wet land under this canal are shown. This area receives the direct seepage from all the upland, and since the underlying beds of gravel are not contiguous to give adequate drainage, the water tends to rise to the surface in places and swamps are formed.

One of the first questions which should be considered in the opening of new farming lands is the drainage. If the natural drainage is good—that is, if the excess of water is quickly removed from the subsoil—the installation of drains is not necessary, but if the water at any time stands within the subsoil or if the excess of water, applied through irrigation or falling as rain, does not quickly pass away through the underground drainage the crops grown upon the land will suffer and the farmer will not obtain the best results from his efforts. The wet land of an irrigated country should be immediately drained when the level of water rises closer than within 3 feet of the surface of the ground. It may be that the water rises near the surface only during a limited period of the year, but this may be long enough to injure a crop.

The underground waters of an irrigated district situated within the arid regions of the West are never free from salts in solution. When this water is allowed to approach the surface of the ground it evaporates, leaving its burden of salt on or near the surface. The salt continues to accumulate in this manner unless the surface water is drained away. Usually such a quantity of salt accumulates that nothing useful will grow upon the land. When reclamation is attempted both the water and salt have to be removed, thus making the work of reclamation very difficult and costly. From the standpoint of economy, therefore, it is much better to install drains before or at least as soon as the ground becomes wet. This will not only remove the excess of water, but will insure the land against ever becoming alkaline.

In the Greeley district the process has as yet gone in most places only far enough to damage the ground from water. If the water is not removed much more damage is probable from alkali. A wet piece of ground is valuable in some cases as pasture, but a piece of badly alkaline land is practically worthless. The underground waters are not

highly charged with salts and the evolution of an alkali flat is slow, but none the less sure. In the shales of the underlying rocks quantities of alkali are stored, and where the seepage water passes through this shale and appears again the accumulation of alkali at the surface is much more rapid.

Repeated tests were made for sodium carbonate, but none was found. This was to be expected, since all of the soils contain small quantities of gypsum, which is the chemical antidote for black alkali.

There is no chemical preparation known which would render the alkali of the Poudre Valley harmless, consequently in order to redeem the lands already damaged these salts must be removed from the soils and removed so far that there can be no possibility of their ever coming back again. There is but one known way of effectively removing these alkali salts, and that is by underdrainage. In the Poudre Valley at present only the lower lands are in need of drainage. The lower lands along the Poudre River and the immediate bottoms of the draws extending back into the hills should be drained at once. In some cases a simple line of drains up the center of the draw would suffice for the present and would insure much of the bottom land from damage. By drawing off the water from the hill land through proper drains in the bottom of the draws, much less water would reach the Poudre bottoms as seepage. The larger tracts of land in the draws and Poudre bottoms should be thoroughly tiled. The shallow basins and sinks offer the most serious difficulties in the construction of drains. Where the basin has a shallow depth the expense of cutting an outlet for the water may be slight, but where the basin is deep the expense of cutting an outlet is liable to be great.

SUMMARY.

Considerable damage has been felt in parts of the Poudre Valley from wet or alkali soils. Such wet or alkali tracts are the natural result of poor drainage. Tile drains should be installed in all the lower lands both to remove the excess of water and to prevent the accumulation of alkali. With continued irrigation of the uplands the amount of possible damage to the lower lands is very great and to insure against this damage the drainage should be commenced at once.

SOIL SURVEY IN THE CONNECTICUT VALLEY.

By CLARENCE W. DORSEY and J. A. BONSTEEL.

INTRODUCTION.

In the present appropriation bill for the United States Department of Agriculture, Congress has specifically authorized the mapping of the soils of the principal tobacco areas of the United States. On the 1st of July, 1899, the Secretary of Agriculture authorized this work to be started in the Connecticut Valley. About three and a half months were spent in surveying the soils of a portion of the valley.

The area is comprised within north latitude 41° 40′ and 42° 17′, and west longitude 72° 30′ and 72° 45′. It extends from South Glastonbury, Conn., where the valley pinches together, northward for a distance of about 41 miles, to Bachelor Brook, in South Hadley, Mass, where the Mount Holyoke range of mountains completely separates it from the extension of the valley from Northhampton northward into Vermont. The valley has an average width of from 5 to 10 miles on either side of the Connecticut River. The area surveyed and mapped comprised approximately 400 square miles, or 256,000 acres.

The object of the work was primarily to investigate and map the different tobacco soils, but incidentally all soil areas were surveyed. Rather full notes were taken as to the general condition of agricultural practice in the valley, the condition of labor, the improved implements used, the construction of barns and other farm buildings, transportation, and other matters contributing to the agricultural features of the locality. Particular attention was paid to the kind of tobacco and the influence of the different soils upon the texture and quality of the tobacco. As this soil work, however, is but the basis of a very extensive and systematic investigation into the physiology of the tobacco, and into the possibilities of changing the type and character of the tobacco through cultural methods and fermentation by the tobacco expert of the division, many of these notes will be reserved for future publication by the division, enough only being given here to make the soil work intelligible and interesting.

One feature which has been very clearly recognized in the course of the survey is the continual and rapid encroachment of city and suburban development for summer residences and for industrial purposes.

Many extensive areas which were formerly considered agricultural lands are now built up or held for speculative purposes for residence or industrial pursuits.

TOPOGRAPHY OF THE VALLEY.

The Connecticut Valley is bounded on either side by hills rising to an elevation of 50 to 100 feet above sea level in the neighborhood of Hartford, and to a little over 500 feet in the northern extension of the area. The difference in the elevation of the river from the upper to the lower portion of the area is but slight, and few falls or rapids occur within this distance. Some water power, however, is developed at a few places along the river. The country is level or gently rolling, sloping gradually back to the high rounded hills and low mountains which form the boundaries of the valley. At places there are still well-defined terraces with sharp escarpments with elevations varying from 10 to 100 feet above sea level.

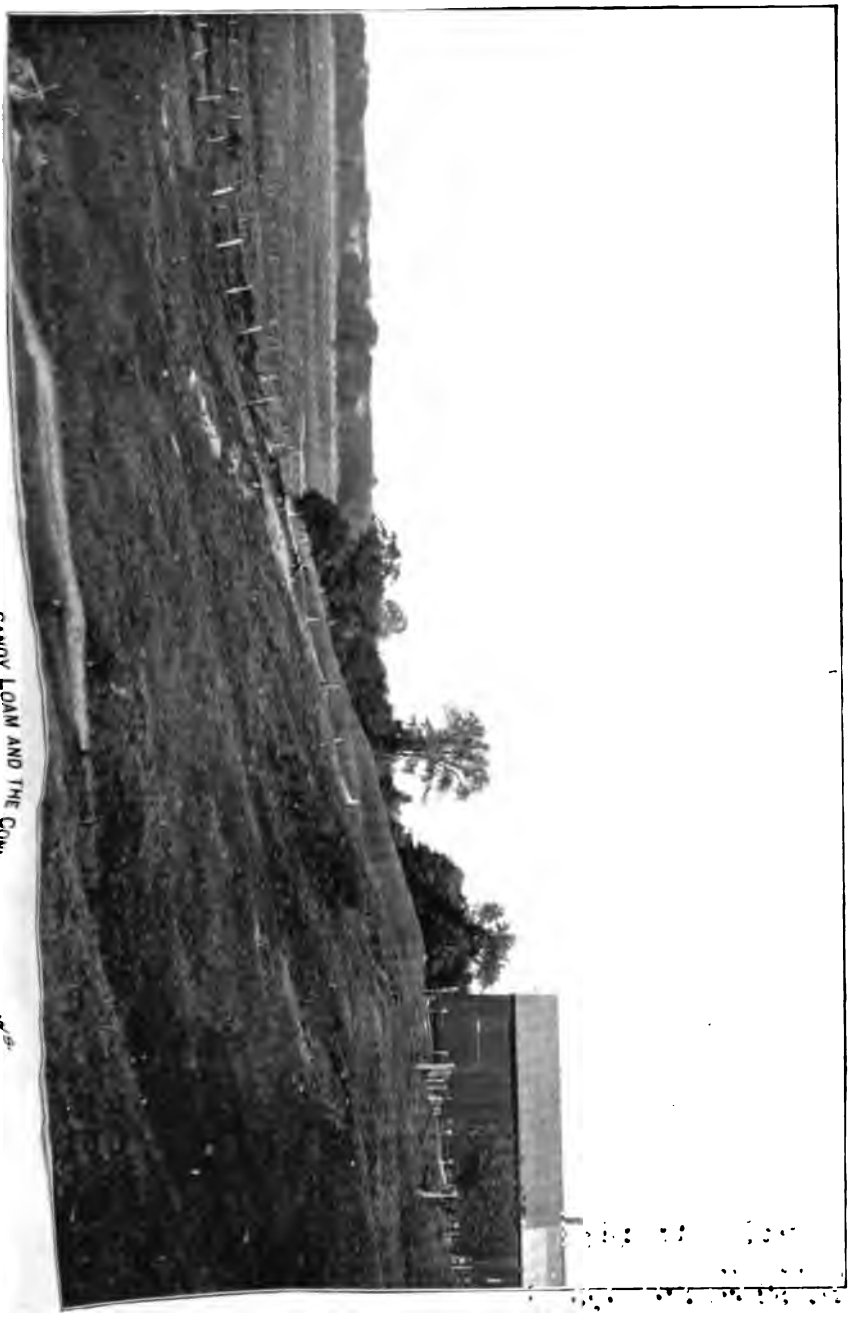
GEOLOGY.

The origin of the soils is partly glacial, which is seen in the great drumlins, or hogbacks as they are called, and the heterogeneous mass of bowlders, sand, and clay bordering the valley and derived from all sorts of rocks; and partly from a shallow glacial lake which is supposed to have spread out over the valley from a dam somewhere below Hartford. Into this lake sediment was brought by rivers and streams. This sediment was sorted over and spread out more or less evenly over the bottom of the lake. As is usual in such cases the deeper and quieter portions of the lake received the finer sand and clays, while the coarse sand and gravels were deposited near the shore line and near the mouths of rivers. These deposits were evidently laid down during the glacial epoch, as arctic plants and leaves are occasionally found in the thin layers of clay and shale, indicating a very different climate than that which now prevails.

After the lake was drained the Connecticut River and its tributaries commenced cutting a series of terraces through the valley. These terraces are not very well preserved, and can not be followed for any great distance, but they are very plain in certain parts of the valley. The character of the formations laid down in these two ways will be described more at length in connection with the soils.

CLIMATE.

The temperature of the Connecticut Valley ranges from 56° F. in May, to 61° in September, with an average of 70° in July, which is the hottest month of the year. The mean maximum temperature ranges from 69° in May to 82° in July, with a mean daily range of 20°. There is on an average about 4.5 inches of rainfall during each month of this



RUNNING FINE SANDY LOAM AND THE CONNECTICUT MEADOWS.

UNIV. OF
CALIFORNIA

growing season, while the mean relative humidity during June, July, and August is about 70 per cent.

Comparing these conditions with the climatic conditions of the other tobacco districts of Cuba, Sumatra, Florida, and Pennsylvania, it would seem that the temperature is sufficiently high for the production of either a wrapper or filler leaf. The rainfall appears to be sufficient, provided it is well distributed during the season; but the daily range in temperature is much greater than occurs in either Cuba or Sumatra, and this very likely has a great deal to do with the character of the leaf. With so great a daily range it would tend to thicken the leaf and increase the body. This is counterbalanced, to a large extent, by the light, sandy character of the soil, which is naturally adapted to the production of a thin leaf, provided a rapid and uninterrupted growth can be maintained.

TOBACCO.

The most interesting and most prominent feature in the agriculture of the Connecticut Valley is the tobacco industry, which has given a world-wide reputation to the locality, and has provided work and sustenance to a large number of people.

Tobacco was introduced into the Connecticut Valley as a recognized farm crop in the early part of this century. It was early recognized that it differed greatly in its qualities from the Maryland and Virginia tobaccos. It had less nicotine, less body, and was not so well adapted to pipe smoking or to chewing. It is an interesting historical fact that the first cigars made in this country are reported to have been made in the Connecticut Valley about the year 1802. It may be said to have been the home of the domestic cigar tobacco, as it certainly was the home of the domestic cigar manufacturing.

With the specialization which has since developed in all lines of tobacco industry the Connecticut tobacco has taken its place essentially as a wrapper leaf, and it is not used to any extent at the present time for fillers in domestic cigars. It is essentially a light wrapper, and when dark, heavy wrappers were in style, as periodically happened, especially before the wide introduction and extensive use of the ideal Sumatra wrapper, the cultivation of tobacco in these light soils of Connecticut was largely abandoned and the domestic supply of wrapper leaf came from the heavier soils of Pennsylvania. The torn, coarse, or inferior leaves are used as binders, while the trash and waste from the barn and cutting tables are exported mainly to England and brings from 1 to 2 cents per pound.

The characteristics of a good wrapper leaf, as described by Mr. Floyd,[1] are that it should have but little body, little aroma or flavor, should be very pliable so that it will stretch and cover well, and have good texture, grain, and style, in order that it will appear well on the cigar.

[1] Report No. 62, U. S. Department of Agriculture.

The leaves must be of uniform color and not too large, the 14 to 1[illegible] inch leaves being the most desirable sizes.

While the Connecticut tobacco has long been recognized by the trad[illegible] as the most desirable domestic tobacco for wrapper purposes, yet th[illegible] difference in price shows at once how the tobacco is regarded by manu[illegible] facturers in comparison with the imported leaf. The Connecticut tobacc[illegible] is worth, on an average, about 18 or 20 cents per pound; the Sumatr[illegible] tobacco, imported exclusively for wrapper purposes, pays a duty o[illegible] $1.85 per pound and sells on the market for from $2.50 to $3 per pound[illegible] duty paid. The Connecticut leaf is too large for an ideal wrapper; being often from 26 to 30 inches in length, the veins are very large, and only the tip of the leaf is suitable for high-priced cigars. Either on account of the physiology of the leaf or in the method of case sweating the desirable grain, color, and style are confined to the tip of the leaf, the lower half being glossy and very undesirable for wrapper purposes. This makes a great deal of waste, which can only be marketed in foreign countries at an exceedingly low price. Lastly, the tobacco is more highly flavored than is desirable for wrapper purposes and frequently masks the desirable qualities of the filler used in the cigar. These defects, as already stated, are to be made the subject of an exhaustive inquiry in the Division of Soils.

One of the objections urged by the manufacturers against the Connecticut tobacco, a fact which certainly largely reduces the price paid for the crop, is the unevenness of color and the poor grading as to color, length, and quality of leaf. In order to maintain a uniform brand of cigars, a manufacturer is forced to purchase a large amount of Connecticut leaf from which to select. Furthermore, on account of the difference in length and in texture of the leaves, there is considerable waste, which is difficult to estimate. It is hard to plan, therefore, for an economical use of the product when a purchase of this tobacco is made. This is not the case with the carefully sorted Sumatra.

One of the reasons which makes the quality of the leaf uncertain and varied is believed to be the method of fermenting in cases, the result of which is largely uncertain and dependent upon chance conditions, which are difficult to understand and impossible to properly control. It is believed by the tobacco experts of the Department that the bulk method of fermentation, as practiced in Florida and in Cuba, will give much more uniform and more desirable results.

The principal reason why the assortment and grading are not so closely done is the high cost of labor. There is so much demand for labor in the shops and factories that the farmer is forced to pay a high price for help. The most successful farmers, therefore, have been those who have cultivated small tracts of from 5 to 15 acres in extent and have made the crop by themselves, with such help as their families could supply, and with occasional hired labor. The Connecticut farmer has to pay about $1.50 per day, where the Florida planter pays about

ents per day for labor. It has always been found, however, that ne exhilarating climate of the North the more energetic laborers do nuch more work in a given time and to so much better purposes ; successful competition is possible in many lines along which at ; sight the outcome would appear at least uncertain. It must be embered, furthermore, that much of the most successful tobacco wing in Connecticut is done by the farmer and his family, so that a ier system of fermentation and of sorting and grading could be done hem during the slack time of the winter months, when other work not pressing, and without greatly increasing the actual expendi-) of money in the production of the crop.

a Sumatra the cost of labor is very much less, even, than in Florida, this is one reason why the Sumatra planters are able to give the reme care to the assortment and classification of their tobacco. It st be remembered, also, that in a fancy assortment of well-cured and ice tobacco the price is largely speculative, as there is no sharp is upon which to fix a commercial value. When from the superior ellence of the leaf the price goes beyond 30 cents per pound it is ble to increase in wider and wider units to $1, $2, and even $3 or $4 pound, according to the fancy of the purchaser and the skill of the ducer in working up a trade and supplying special demands. This been shown in a very marked way in the development of the tobacco lustry in Florida, where high prices are obtained by a few packers o understand the market requirements and can judiciously place ir products, while a very low price is obtained by the average grower, o is less able or less willing to make the product required by the de, and who is unable to make advantageous trade connections.

There is one interesting feature in regard to the tobacco industry in e Connecticut Valley, namely, that through the improved methods of nting and cultivating the crop the season of growth is being very terially shortened. In 1899 the growing season was about two weeks orter than was ever known before. Tobacco set out the middle or st of May was fully matured by the middle of July.

SOILS.

The object of the soil survey is to classify and map the soils accord- g to any condition which might influence the character of the vegeta- on, especially the character of the tobacco, the kind of crops adapted) the land, and the quality as well as the quantity of the crops grown. he soils of the Connecticut Valley have been classified in this way as result of the season's work, and a map has been prepared, accom- anying this report, showing the area and distribution of the various ypes of soils which were recognized. As before stated, this work will)rm the basis for a more extensive investigation of the Connecticut obacco, and, pending such fuller investigation in regard to the char- cter of the tobacco, only brief mention will be made at this time of the

relation of the soils to the character of the leaf which they produce. So many other questions enter in regarding the variety of seed used, the method of cultivation, fertilization, and fermentation, as well as the personal equations of the growers, that require the careful investigation and judgment of the tobacco expert, that only passing mention should be made at this time and in this connection of the character of the crop produced on the different soil areas.

TRIASSIC STONY LOAM.

As already mentioned, the Connecticut Valley is bounded on either side, from the southernmost part of the area surveyed up to Westfield and Mill River, just below Springfield, by a glacial deposit consisting mainly of Triassic sandstone débris forming long lenticular hills, drumlins, or hogbacks, between which the surface is rolling and hilly, with a few long ridges and groups of rounded hills varying in elevation from 40 to 400 feet. A few areas of this glacial débris are scattered about in the valley proper, and from the fact that they are not covered with lake sediment it may be assumed that they were formerly islands in the glacial lake, or else the covering has since been removed by erosion.

The Triassic stony loam soils are fine sandy loams, dark Indian red in color, mixed with gravel and bowlders of all sizes and shapes, varying in size from an inch to 6 or 8 feet in diameter. The amount of gravel and undecomposed rock exceeds 5 per cent in all cases, and may exceed 50 per cent. In many cases fields are now comparatively free from these bowlders and large rocks on account of the numerous times they have been picked over and stones removed. Indeed, the surface of this geological area has been very greatly modified by the hand of man. Cultivated fields may contain only a few scattered stones, while the surface of the area surrounding the field may be covered with a mass of stones and bowlders. The stones, especially the smaller ones, and the fine gravel are derived principally from the Triassic sandstone and shales.

Tobacco is grown to a considerable extent in certain areas in the Triassic stony loams. It is considered a fat tobacco, and has an undesirable cinnamon color, but it is readily bought up at good prices for special market demands. The character of the tobacco is quite different from that grown on the other tobacco soils of the valley, and there is a long-standing controversy as to the relative merits of this and of the tobacco from other soils. The fact of the matter is that they are used largely in different channels, and are to a great extent bought up by different dealers. There are large tobacco centers around Day Hill, south of Poquonock, around Warehouse Point, Suffield, and Enfield street. The best development of the tobacco industry on this formation is probably around Suffield and Warehouse Point. The Havana seed is exclusively grown on this formation. The other areas outlined on the map have soils of fair condition, but are not farmed to any great

TRIASSIC STONY LOAM.

These stones were picked off year after year to provide for cultivation.

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extent. They are given up mainly to pasture lands, meadows, and orchards. The following table gives the mechanical analysis of the Triassic stony loam subsoils:

Mechanical analyses of subsoils of Triassic stony loam.

(Fine earth.)

Diameter.	Conventional names.	4211. Bloomfield, ½ mile S.	4212. Enfield.	4201. Hazardville, 1½ miles S.
Millimeters.		*Per cent.*	*Per cent.*	*Per cent.*
2 to 1	Gravel	2	12.45	5.26
1 to 0.5	Coarse sand	3.35	11.86	8.66
0.5 to .25	Medium sand	8.60	13.98	18.83
.25 to .1	Fine sand	31.25	14.78	21.00
.1 to .05	Very fine sand	34.22	17.51	18.83
.05 to .01	Silt	4.35	8.20	8.70
.01 to .005	Fine silt	6.20	8.67	5.30
.005 to .0001	Clay	6.57	10.23	10.87
	Loss at 110° C.	1.36	1.04	1.01
	Loss on ignition	2.03	1.69	1.77

HOLYOKE STONY LOAM.

The hills bounding the northern extension of the area examined, with elevations from 240 to 500 feet above sea level, are likewise glacial deposits, but formed of diabase, crystalline, and metamorphosed rocks. The surface of the country of what may be called the foothills is rolling with steep slopes and containing many lenticular hills and groups of rounded hills. The surface is rough, and in places large masses of bowlders are lying as they were piled by the ice, and with hardly any perceptible disintegration. Many of the slopes are entirely covered with these bowlders. The soil is a sandy loam, containing from 10 to 50 per cent of gravel and bowlders, ranging in size from 1 inch to 12 or 15 feet in diameter. The following table gives the mechanical analysis of the fine earth of a sample of Holyoke stony loam:

Mechanical analysis of subsoil of Holyoke stony loam.

Diameter.	Conventional names.	4203. Ashleyville, 2 miles S.
Millimeters.		*Per cent.*
2 to 1	Gravel	3.05
1 to 0.5	Coarse sand	3.85
0.5 to .25	Medium sand	8.22
.25 to .1	Fine sand	11.53
.1 to .05	Very fine sand	29.82
.05 to .01	Silt	21.26
.01 to .005	Fine silt	6.45
.005 to .0001	Clay	12.20
	Loss at 110° C.	1.54
	Loss on ignition	2.35

The soils are derived entirely from the glacial débris. The soils are not fertile, and are not farmed to any great extent. There are occasional patches of corn, oats, and rye, but no tobacco. They are mainly given up to stony pastures and orchards.

WINDSOR SAND.

The generally accepted idea of the origin of the soils of the valley proper has already been referred to. It is supposed that during glacial times a dam extended across the valley below Hartford, forming a shallow lake of considerable extent, and comprising all of the area which has been surveyed this season. The streams collecting the drainage from the surrounding country emptying into the lake brought sediments, which were sorted over and deposited in different places, according to the direction of the currents, the depth of the lake, and the velocity of the water. The coarser sands and gravels would be deposited near the shore line and the mouth of the streams, while the finer sands and clays would be deposited off shore, and in deeper and quieter portions of the lake.

As the level of the water of the lake was lowered from time to time well-marked shore lines, constituting terraces, were formed out of the material which had previously been deposited, and out of fresh material which had been emptied into the lake. This gave rise to a series of terraces, more or less well preserved at the present time, but greatly cut up and modified by recent stream action, and by the meanderings of the Connecticut River.

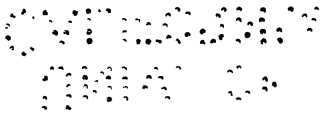
The Windsor sand represents what is supposed to be the original bottom of the old glacial lake in its shallowest parts. The soil is composed of yellowish-red or brown sand, resembling a coarse sharp building sand, and containing less than 5 per cent of clay. The material contains about 5 per cent of coarse gravel, ranging in size from 2 to 10 mm. in diameter. This gravel content increases to some extent in the subsoil. In places this formation is 40 feet deep. The following table gives the mechanical analyses of four samples of Windsor sand:

Mechanical analyses of subsoils of Windsor sand.

Diameter.	Conventional names.	4210. Bloomfield, 2 miles SE.	4198. Windsor Locks, 3 miles SW.	4199. Hubbards Corners, 1¼ miles NW.	4200. Chicopee, 2 miles SW.
Millimeters.		*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
2 to 1	Gravel	4.98	8.00	2.52	14.30
1 to 0.5	Coarse sand	11.31	15.83	12.32	26.28
0.5 to .25	Medium sand	33.41	39.90	39.29	30.35
.25 to .1	Fine sand	33.75	22.21	27.92	9.55
.1 to .05	Very fine sand	10.82	6.56	7.30	6.02
.05 to .01	Silt	2.09	3.20	4.33	4.66
.01 to .005	Fine silt	1.03	1.20	1.62	2.73
.005 to .0001	Clay	1.65	2.25	3.15	4.87
	Loss at 110° C	.50	.45	.48	.50
	Loss on ignition	.80	1.00	1.84	1.47

The soils are coarse and inclined to be leachy or droughty, but, like many soils of this character, are generally somewhat moist beneath the top few inches of dry sand throughout the most severe drought. The soils are good representative truck soils and are used for this purpose in some parts of the area.

WINDSOR SAND SHOWING OLD CORN ROWS COVERED WITH FOREST GROWTH.



In favorable seasons a very fine quality of thin-leaved silky tobacco is produced on these soils, the finest probably that is produced on any of the soils of the valley, but the season has to be just right, and such favorable conditions hardly occur more than two years out of five. If a crop by any means can be kept growing rapidly and continuously, it will produce a fine silky leaf excelled by none of the other soils in the valley. In average seasons, however, the growth is liable to be checked by changing weather conditions, and the plant is small and produces a leaf which is thick and strong. It is desirable to plant early on these lands and give constant and thorough cultivation.

The Windsor sand comprises a large part of the Windsor Plains in the towns of Windsor, Bloomfield, East Granby, and Windsor Locks, as well as a small area in East Hartford. The surface of the area in Connecticut is level or gently rolling, ranging from 100 to 180 feet in elevation. The area in Massachusetts is much larger and covers in all about 30 square miles. It is largely developed in the towns of Agawam, West Springfield, Springfield, Chicopee, and Long Meadow. The surface is much more rolling than in Connecticut, and ranges in elevation from 100 to 240 feet.

For the most part the area of Windsor sand is not very extensively cultivated at the present time. In Agawam there is some truck farming, a few peach orchards, and some tobacco grown. East of Springfield the area is rapidly building up in the extension of the city. In Connecticut there are but few houses, deep sandy roads, and many old and unsuccessful fruit farms. Many areas which were formerly cultivated are now grown up in the characteristic forest growth of pine. The soil is so open and porous and offers so little resistance to the entrance of rain water that the surface hardly washes at all, and there are old corn rows running through the forests and well preserved, upon which the trees must be at least 50 to 80 years old. Many of the old furrows thrown up in the original measurement of the land are still plainly distinguishable.

HARTFORD SANDY LOAM.

The Hartford sandy loam occupies by far the largest extent, and plays the most important part in the tobacco industry in the Connecticut valley. It extends from Glastonbury to South Hadley, and covers in all an area of over 80 square miles. A portion of it is probably the undisturbed old lake bottom, but there are also more recent river-cut terraces. The formation occurs in broad terraces, which are very level in places and gently rolling in others. The formation is found at elevations ranging from 30 to 260 feet above sea level. The soils are red, brown or yellow, medium grade sandy loams, about 12 inches deep, underlaid with yellow sands, containing little or no organic matter. The soil is a grade finer than the Windsor sand, as is apparent from the analysis, and is correspondingly stronger, and decidedly safer as an agricultural soil. The deposit varies in depth from about 3 feet to 20

feet. It differs again from the Windsor sand in having no gravel, or but a mere trace of very fine gravel in a few places. The following table gives the mechanical analyses of five samples of Hartford sandy loam:

Mechanical analyses of subsoils of Hartford sandy loam.

Diameter.	Conventional names.	4204. Windsor, SW.	4205. East Long Meadows, 2 miles NW.	4214. Burnside, ½ mile SW.	4213. South Windsor, 2 miles E.	4215. Burnham, 1 mile E.
Millimeters.		*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
2 to 1	Gravel	2.20	0.00	2.23	Trace.	4.11
1 to 0.5	Coarse sand	7.51	.31	7.78	6.84	11.83
0.5 to .25	Medium sand	33.50	2.84	25.25	42.86	29.29
.25 to .1	Fine sand	32.05	63.10	29.00	32.20	24.45
.1 to .05	Very fine sand	13.50	29.15	25.40	7.78	12.72
.05 to .01	Silt	4.47	1.15	3.45	2.62	3.46
.01 to .005	Fine silt	1.75	.96	2.10	1.70	3.29
.005 to .0001	Clay	2.78	1.42	3.22	3.80	5.29
Loss at 110° C.		.80	.50	.77	.76	2.96
Loss on ignition		1.30	.90	1.27	1.54	2.81

The general crop of Connecticut seed-leaf tobacco is grown on these soils. This represents what may be called the typical tobacco soil of the Connecticut Valley, and the safest and therefore the best soil at least for the seed-leaf variety. Corn and potatoes do well on these soils, and about Hockanum and south of Willow Brook, in East Hartford, considerable truck farming is carried on. Southwest of Hazardville the soil for some reason appears less coherent, and drifting sand dunes are common. The yield of tobacco on this soil varies from 1,500 to 2,000 pounds per acre, or even a little more. The average price of the crop is about 18 cents a pound, but the lands are heavily fertilized. Labor is high and the crop as a whole is expensive to make. Tobacco is grown mainly in small fields of from 3 to 10 acres, 15 acres being an unusually large tract. There are many large areas of this still undeveloped upon which a good quality of tobacco can be produced.

PODUNK FINE SANDY LOAM.

The Podunk fine sandy loam represents river cut terraces, ranging in elevation from 20 to 80 feet above sea level. There is in all an area of only about 7 or 8 square miles of this in the area surveyed, and of this only about ½ square mile in East Hartford has contributed largely to the fame of the Connecticut Valley in the production of the broad-leaf variety, which differs in many essential characteristics from the Habana seed-leaf grown on the Hartford sandy loam. The surface of the areas are level or very gently rolling. The soil is a dark-brown sandy loam, about 12 inches deep, and of most excellent tilth. The subsoil is a dark-brown sandy loam of the same texture as the soil, but differing in color, as it has less organic matter. The following table gives the mechanical analyses of two samples of Podunk fine sandy loam:

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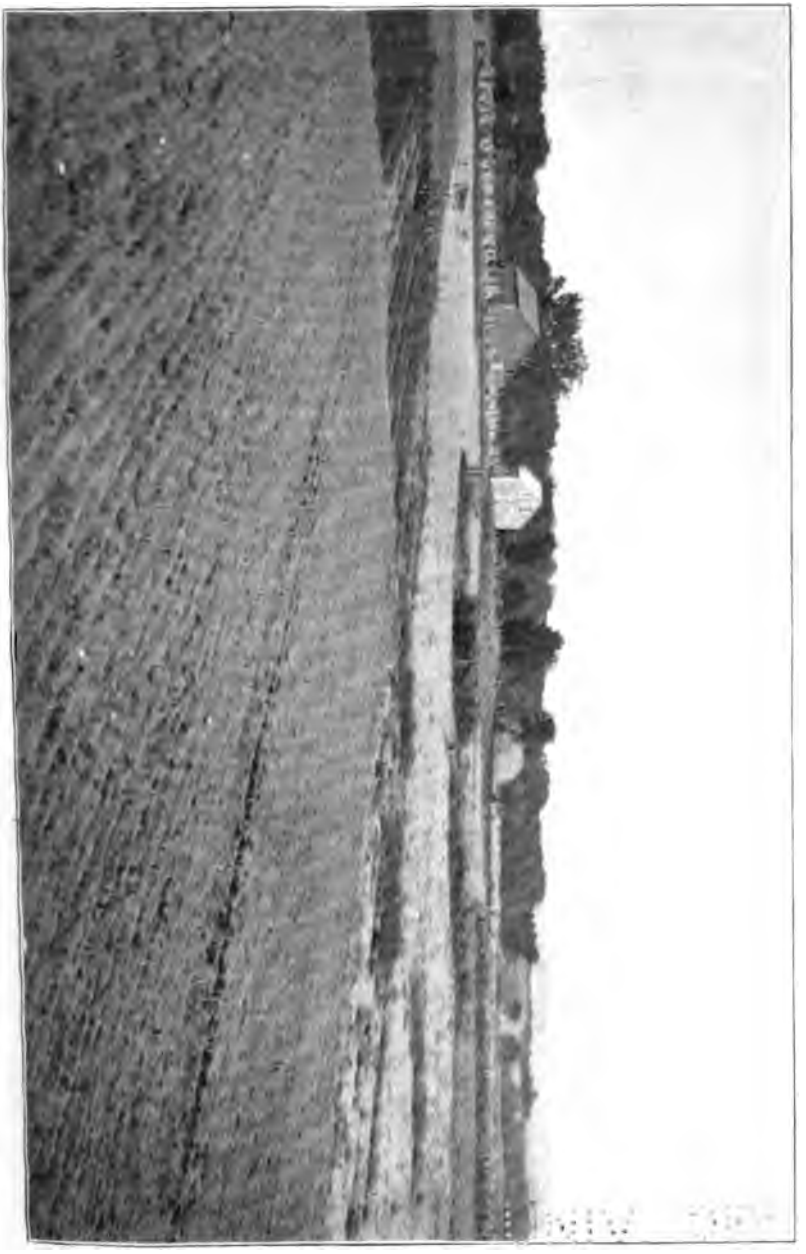


THE HARTFORD SANDY LOAM.

Mechanical analyses of subsoils of Podunk fine sandy loam.

Diameter.	Conventional names.	4206. Agawam, 1 mile NW.	4216. South Windsor, ½ mile NE.
Millimeters.		*Per cent.*	*Per cent.*
2 to 1	Gravel	0.00	0.50
1 to 0.5	Coarse sand	.07	1.51
0.5 to .25	Medium sand	1.53	7.96
.25 to .1	Fine sand	41.80	23.27
.1 to .05	Very fine sand	49.00	41.82
.05 to .01	Silt	3.43	9.15
.01 to .005	Fine silt	1.02	6.32
.005 to .0001	Clay	1.70	4.40
	Loss at 110° C	.66	1.92
	Loss on ignition	1.08	3.68

The soils are a grade finer in texture than the Hartford sandy loams, and while well drained are strong, safe, and productive. The areas are all thickly settled, and, with the exception of that in the town of Agawam, are very highly cultivated and well cared for. The South Windsor and Naubuc districts, particularly, are famous broad-leaf tobacco areas.

The broad-leaf variety is heavier and has a thicker leaf than the seed-leaf, is generally darker in color, and is a better leaf for cutting purposes. It has not the undesirable "seed" flavor of the Habana seed-leaf, and is preferred by many smokers. It yields more per acre than the Habana seed on the Hartford sandy loams, but, with all, it has a rougher look in the cigar. For this reason it is not in such good favor with many cigar manufacturers as the finer, silkier Habana seed grown on the Hartford loams. It is considered better by the farmers in this Poduuk region to plant tobacco continuously rather than to use a rotation. There are fields which have been continuously in tobacco for twenty-five years, and which it is claimed are as productive and produce as fine tobacco as at any period of their cultivation. This broad-leaf variety is grown to a limited extent upon the small area of Hartford sandy loam east of Connecticut River, near South Windsor, but, with this exception, it is confined to the Podunk soil. Corn and potatoes do well on this soil. The Agawam area has not been very successfully farmed for the past few years, for some unexplained reason, and there is a chance of development there which should certainly arrest the attention of tobacco growers.

CONNECTICUT MEADOWS.

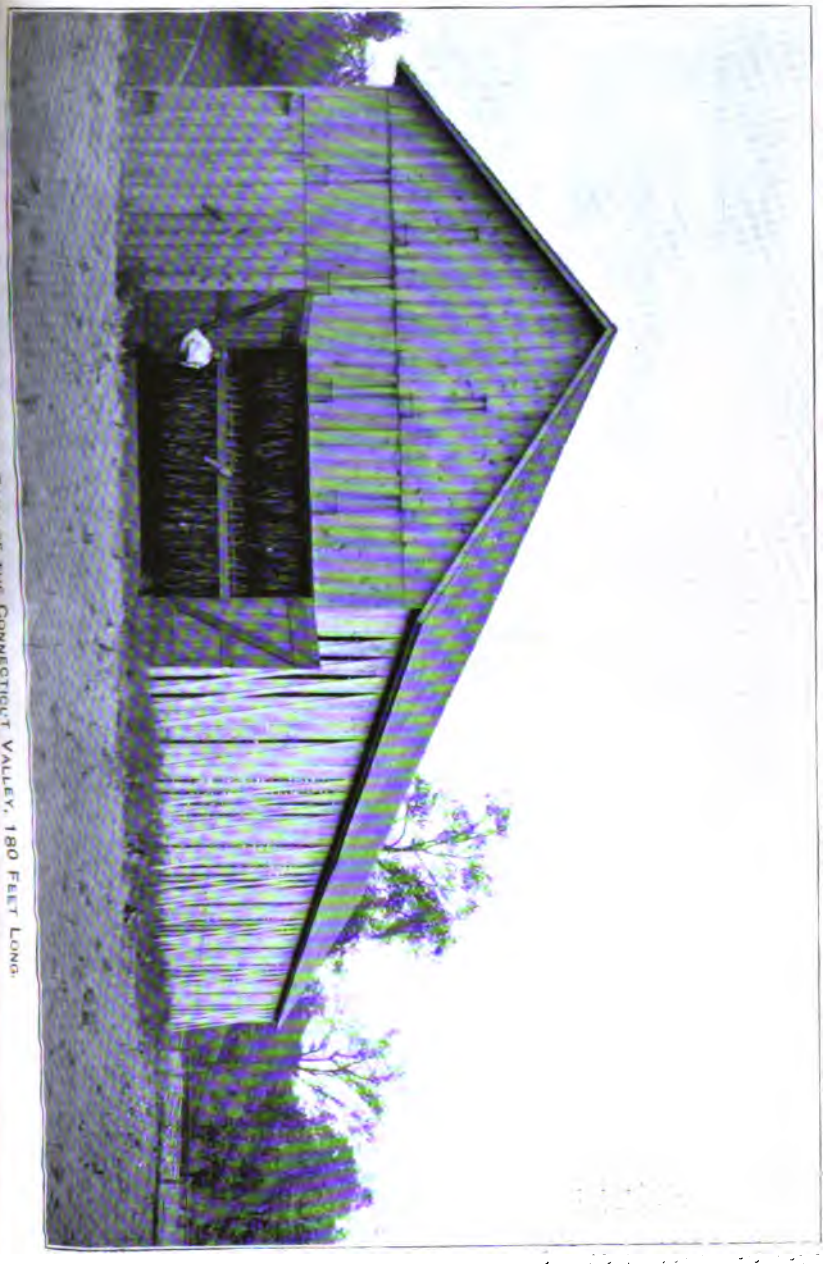
The Connecticut meadows occur as narrow strips on either side of the Connecticut River from Holyoke south to Long Meadow, Mass., and from Warehouse Point to South Glastonbury, Conn. There are smaller areas along the various tributaries of the Connecticut River. This represents the present flood plain of the Connecticut River and its tributaries, being built up at the present time by deposits from the flood

waters. The river will finally build up this terrace so high that it can no longer spread over it, and new terraces will be constructed at lower levels. The surface of the meadows is generally higher along the river bank and, of course, better drained there. There is a gentle slope down to the scarp connected with the upland or next higher terrace, and this area immediately below the upland is frequently wet and swampy. The meadows are all subject to overflow at time of very high flood, but in spite of this there is considerable farming on them, although at some risk of the loss of the crop. Surface of the meadows is level or gently rolling, with occasional old stream channels or run-ways in them. The surface of the meadow is from 5 to 20 feet above sea level at Hartford and from 40 to 80 feet above sea level at Springfield and Holyoke. The material of which the soils are composed has been brought in by the rivers at flood time, but there is no evidence of stratification, probably on account of the wind and rain action between the comparatively long periods between the floods. The character of the material is very uniform throughout all the areas. It is very fine sand and silt, being uniform in places to a depth of 10 feet and over, resembling loess in many of its characteristics. It is a grade finer than the Podunk fine sandy loam. The soil is from 16 to 18 inches deep, contains a large amount of organic matter, consists mainly of very fine grades of sand and silt with but little clay, and is considered extremely fertile and productive. The subsoil is grayish in color, but otherwise hardly different from the overlying soil. The following table gives the mechanical analyses of four samples of subsoil from the Connecticut meadows:

Mechanical analyses of subsoils of Connecticut meadows.

Diameter.	Conventional names.	4207. Chicopee, 2½ miles N.	4217. Hartford, ½ mile SE.	4218. S. Windsor, ½ mile NW.	4219. Windsor, ½ mile SE.
Millimeters.		*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
2 to 1	Gravel	0.00	0.00	0.00	0.00
1 to 0.5	Coarse sand	Trace.	Trace.	Trace.	.00
0.5 to .25	Medium sand	0.37	0.21	0.36	.31
.25 to 1	Fine sand	6.87	1.50	2	1.77
.1 to .05	Very fine sand	50.86	19.55	14.78	9.79
.05 to .01	Silt	28.49	33.67	36.50	30.25
.1 to .005	Fine silt	6.60	28.54	27.17	29.47
.005 to .0001	Clay	3.35	9.50	13.40	19.11
Loss at 110° C		1.10	2.60	2.50	4.13
Loss in ignition		2.60	4.75	3.54	5.31

Generally the meadow soils produce a dark, heavy, low grade of tobacco. When dark cigars were in style, as they were fifteen or twenty years ago, these meadow lands produced a tobacco which was much more in favor than it is at the present time. Very good tobacco can be grown on high meadow land if it be well drained, but there is an almost universal prejudice against it and it brings a low price from the mere association with the name of meadow land. There is an area of high meadow land west of East Windsor hill which is never overflowed



A TYPICAL TOBACCO BARN OF THE CONNECTICUT VALLEY, 180 FEET LONG.

the river, resembling the Podunk fine sandy loam and classed with ıpon which there is a very good quality of tobacco produced, but ich suffers from the mere association with the name of meadow land. ı large proportion of the Connecticut meadows is used only for ss, several crops being cut in the course of the year. Areas where y well drained are used for corn and potatoes, and in some cases for ıry and general truck farming. Below Merrick the meadows are ed to keep out the high water and insure the land from overflow, but ı is the only place where this has been done to any extent.

'he Connecticut meadows, Podunk fine sandy loam, Hartford sandy m, and Windsor sand represent four important and representa- ı soils of higher and higher average elevation and of coarser and rser material, which represent the most extensive and most impor- t soil areas in the valley. The difference in texture of these soils very marked and very apparent to the eye, and this difference in ture determines to a large extent the relation of the soils to crops, l particularly to the quality of the tobacco produced.

ENFIELD SANDY LOAM.

On either side of the valley, in terraces around the hills of the Trias- ı stony loams and filling up depressions at elevations ranging from to 240 feet, there is a fine sandy deposit, resembling the Hartford ndy loam, directly over the Triassic stony loams which occurs at a pth of about 2 feet below the surface. The outward extension of the rraces grades into the Hartford sandy loam, where the Triassic stony am is 3 feet or more below the surface. The underlying Triassic ony loam provides a retentive subsoil, and these soils retain moisture ıtter and are rather stronger than the Hartford sandy loams, which ey resemble in other respects. The following table gives the mechan- al analysis of a sample of Enfield sandy loam:

Mechanical analysis of subsoil of Enfield sandy loam.

Diameter.	Conventional names.	4202. East Hartford, E.
Millimeters.		*Per cent.*
2 to 1	Gravel	4.22
1 to 0.5	Coarse sand	5.05
0.5 to .25	Medium sand	7.75
.25 to .1	Fine sand	10.43
.1 to .05	Very fine sand	43.60
.05 to .01	Silt	13.53
.01 to .005	Fine silt	4.86
.005 to .0001	Clay	5.57
	Loss at 110° C	1.82
	Loss on ignition	3.22

A very good quality of Habana seed-leaf tobacco is grown to limited extent on these soils, especially around Melrose, Osborne, Wa ping, and south of Poquonock. The characteristic feature of this s as distinguished from the Hartford sandy loam is the occurrence the Triassic stony loam at a depth of from 12 to 24 inches. The are along the eastern part of the valley are generally thickly settled. other parts of the valley there are large areas still uncleared and unc tivated.

SUFFIELD CLAY.

The Suffield clays occur principally at Windsor, East Windsor, a Suffield, with occasional small areas along the scarp between the Co necticut meadows and the upland. These soils are found at elevatio varying from 40 to 220 feet above tide. The surface is gently rollin except along the scarps, where the slopes are liable to be quite ste The soils are heavy clay loams, grading down into drab clays w exceedingly poor drainage, making the surface cold and wet. The f lowing table gives the mechanical analyses of two samples of Suffi clay:

Mechanical analyses of subsoils of Suffield clay.

Diameter.	Conventional names.	4208. Suffield.	4209. Riverdale, W.
Millimeters.		*Per cent.*	*Per cent.*
2 to 1	Gravel	0.00	0.00
1 to 0.5	Coarse sand	.29	.00
0.5 to .25	Medium sand	.40	.00
.25 to .1	Fine sand	.73	.15
.1 to .05	Very fine sand	5	11.27
.05 to .01	Silt	32.57	38.58
.01 to .005	Fine silt	29.10	24
.005 to .0001	Clay	25.65	23.50
	Loss at 110° C	2.17	1.10
	Loss on ignition	3.53	1.50

The Suffield clays have little value as agricultural lands, and a mostly given up to grass and pasture. There are large areas which a not cultivated at all, and growing up in a tangled mass of worthle underbrush. Around Springfield, Holyoke, and Hartford there a large brickyards making brick of this clay. No tobacco is grown i any part of this area, as the soils are entirely unsuited to this crop.

ELMWOOD LOAM.

The Elmwood loam occurs in large areas around Hartford, Windso and South Hadley. The soil consists of a deposit of fine yellow sandy loam, about 24 inches deep, overlying laminated drab clays, similar i all respects to the Suffield clays. The clay is a deep lake deposit, whil the overlying sand is a shallow lake or river deposit. The followin table gives the mechanical analysis of a sample of Elmwood sandy loam:

Mechanical analysis of subsoil of Elmwood sandy loam.

Diameter.	Conventional names.	4220. Elmwood, 3 miles N.
Millimeters.		*Per cent.*
2 to 1	Gravel	0.00
1 to 0.5	Coarse sand	0.45
0.5 to .25	Medium sand	3.76
.25 to .1	Fine sand	17.53
.1 to .05	Very fine sand	59.82
.05 to .01	Silt	7.03
.01 to .005	Fine silt	4.65
.005 to .0001	Clay	4.00
	Loss at 110° C	1.45
	Loss on ignition	1.90

The surface of the ground is rolling and hummocky. The soil is found elevations varying from 20 to 80 feet above sea level at Hartford, and om 160 to 200 feet at South Hadley. Around Hartford the Elmwood am gives fairly good grass and pasture lands, but is not cultivated to y extent except for small garden patches. North of Hartford it is ither cleared nor cultivated. The area around Hartford is rapidly eing built up in the suburbs of the city. A few small areas have been cultivated in tobacco, above Windsor, but the soil is not adapted to tobacco cultivation.

CONNECTICUT SWAMP.

Considerable swamp land and wet meadows occur scattered over the entire valley at various elevations. They occur generally along the scarp between the Connecticut meadows and the upland and along a large number of small streams flowing into the Connecticut River. Again in the hollows between hills and slopes, where there is poor drainage, these upland swamps are liable to occur from any cause where the drainage is poor and the soil almost impervious to water, with swampy, wet conditions as a characteristic feature. No matter at what elevation they may be found these are all classed as Connecticut swamps. The swamps are all of fresh water and they are all at present too wet for cultivation. Some of the areas can be easily drained, while others immediately along the river could not be reclaimed except at great expense. Most of them along the river are wet throughout the year. Some of them are sufficiently dry during the summer so that the coarse, rank meadow grass produced may be mowed and saved for rough forage. The character of the soils of these areas has not been determined. They are very small in extent and of little agricultural importance. Many of them represent merely obstructed drainage areas which by underdrainage could readily be reclaimed.

COMPARISON OF THE TEXTURE OF THE SOILS.

The following table gives a clear idea of the texture of the soils the Connecticut Valley, and explains to a great extent the distributi of crops and the difference in the characteristics of the tobacco gro on the different soil areas:

Windsor Plains, 65 per cent gravel to medium sand, 30 per cent fine and very f sand.

Triassic stony loam, 35 per cent gravel to medium sand, 40 per cent fine and v fine sand.

Enfield sandy loam, 17 per cent gravel to medium sand, 55 per cent fine and very f sand.

Diabase stony loam, 15 per cent gravel to medium sand, 40 per cent fine and v fine sand.

Hartford sandy loam, 65 per cent medium to fine sand, 90 per cent medium to v fine sand.

Podunk loam, 40 per cent fine sand, 90 per cent fine and very fine sand.

Connecticut meadows, 50 per cent very fine sand, 80 per cent very fine sand and s

Suffield clay, 35 per cent silt, 50 per cent fine silt and clay, 25 per cent clay.

PLICATION OF THE THEORY OF SOLUTION TO THE STUDY OF SOILS.

By FRANK K. CAMERON.

INTRODUCTION.

n the course of the work of this laboratory within the last year we e had occasion to examine chemically quite a number of soils and crusts from the arid regions. These soils have been of the class wn as "alkali soils"; that is, they contain a relatively large per-tage of water-soluble salts. The origin and presence of these salts e been discussed in the publications of this Division and elsewhere, hat we may assume, for the purposes of this paper, that this part of the ject has been made sufficiently familiar to those who may be interested. he salts which go to make up these crusts or water-soluble constitu-s of the soils are, in general, sodium chlorid, magnesium chlorid, cal-m chlorid, sodium sulphate, magnesium sulphate, calcium sulphate, l sodium carbonate with, occasionally, much smaller quantities of er salts which may be regarded as relatively unimportant. It is ual to find several of these salt components together in an alkali soil. When sodium carbonate is a component of the salts present then the t mixture is known as "black alkali," because of the charring and stic effect of the sodium carbonate on the organic matter present ing a characteristic black color to the soil. In contradistinction, en sodium carbonate is *not* a component, these salt mixtures are own as "white alkali," because, in general, they do not show this rkening effect but effloresce on the surface as a white crust if present sufficient amount. It is to be remembered, however, that local ter-nology is not always in full accord with this distinction; for instance, New Mexico, in the Pecos Valley, there are tracts of land, quite dark appearance, containing much water-soluble salts or alkali, which are cally called "black alkali" land, although examination fails to show e presence of any sodium carbonate.

The chemical examination or analysis of these water-soluble salts in e soils yields results which, in many cases, seem very remarkable at st sight in the relatively large percentage of salts usually regarded sparingly soluble—notably sulphates and carbonates of lime—and e question how they have been dissolved and transported in such large

quantities is a natural one. When we attempt to dissolve these salts water, in order to remove them from the soil, just such surprising results are obtained in our solutions in the relatively large quantities dissolved under certain conditions. In order to understand these phenomena and to make our analyses intelligible it will be desirable to have in mind the laws governing solutions which apply to such cases.

NATURE OF SOLUTIONS.

Before discussing these laws it seems well to state more precisely what is understood by the term solution, and as we are concerned chiefly with solutions of solids in liquids we shall not stop to make any modifications which other solutions would necessitate.

The most striking characteristic of a solution is its homogeneity; that is to say, after it has come to equilibrium every part of the solution is just like any other part in all its physical and chemical properties. Two important exceptions should be noted here. If the solution be one of considerable height or depth the gravitation force comes in evidence, the lower portions of the solution are more dense, the higher portions less so, and there is a corresponding variation in other properties. But even here it will be observed that there is no sudden break in the properties. They will vary regularly and continuously as we go from the top to the bottom. Again, it has been observed in the case of solutions in contact with solids (the walls of the containing vessel, for instance) that in portions very near the surface there is often a concentration of the dissolved material. This phenomenon has been called ad-sorption. The growth of crystals on the surface of solids introduced into the solution is probably due to this cause; the difficulty of washing certain solutions through a filter paper, where often a portion of the dissolved substance will linger after the most persistent washing, is a well-known example of this phenomenon.

Another important characteristic of a solution is that all its properties vary continuously with the concentration. The law by which this variation takes place in any specific case may not be evident, and in general it is not, but it may be taken as a well-established principle that there is no sudden jump or change of direction in any physical property, as the concentration gradually changes. The recognition of this fact has come within comparatively recent years. It was long supposed that, while this fact was in general true, there were well marked exceptions. For instance, it has been known since the time of Gay-Lussac that the solubility of Glauber's salt (the decahydrate of sodium sulphate) changed suddenly at about 33° if the temperature was gradually raised. So do all the other physical properties of the solution; such as vapor pressure, refractive power, conductivity, etc. Within comparatively recent years the explanation was offered that below 33° the solution was one of the decahydrate in water, and above that temperature the solution was something different, containing a

ar hydrate or the anhydrous salt. Later study has shown that this r must be modified. There is probably no change in the substance tally in the solution, for in that case we would expect some irregu- ies in the change of physical properties. The difference below and ve this temperature point, 33°, is in the equilibrium between the dis- ed substance and the undissolved salt which may crystallize from saturated solution. It is really the nature of the undissolved salt he given temperature when in contact with the solution that is the trolling factor, and we have in fact two solubility curves in this ticular case which meet in a common point near 33°. When the d decahydrate is warmed to this temperature it partially melts into aturated solution of the anhydrous salt, the excess of anhydrous separating as such.

We are now familiar with quite a number of similar instances of this racter, but in every case investigated a similar explanation has n demonstrated, and this characteristic of solutions has been thor- ghly established as a natural physical law. Indeed, these two prop- ies just described are incorporated in the best definition as yet pro- ed for a solution, i. e., a homogeneous mixture whose properties ry regularly with the concentration.

LAWS GOVERNING SOLUTES.

It has been found convenient in discussing solutions to introduce rtain terms, and, as it will greatly simplify what is to follow, they are re defined. The substance in which the solution takes place is known the *solvent*, and the substance which goes into solution in the solvent called the *solute*.

From the study of the phenomena presented by solutions it has been ry clearly shown that the solute is in a condition strictly analogous a gas—that is, its molecules are perfectly free to move about among emselves within the limits of the solution. Just as the movement of e molecules of a gas results in a pressure on the walls of a containing essel, so the movement of the molecules of a solute will result in a ressure on the walls of a containing vessel; only the medium in which hey are free to move—the solvent—must extend beyond the walls of he vessel and be able to pass freely through them. Vessels with such alls have been realized; they have been filled with a solution, immersed the solvent, and the pressure on the walls of the molecules of the olute—trying to diffuse into the outside solvent—has been measured uantitatively. This pressure, which has been called the *osmotic pres- ure* to distinguish it from the gas pressure known as *vapor pressure*, as been found to be actually the same in amount as the vapor pres- ure would be at the particular temperature, if the substance could be gas at that temperature.

It has long been known that certain relationships hold between the volume, pressure, and temperature for all gases, irrespective of what

the particular nature of the gas may be. The explanation for this, which is universally accepted at the present time, is that in a gas the particles of which it is composed (the molecules, if the molecular constitution of matter be accepted) are possessed of such a large degree of freedom that they are entirely able to move about among each other without this motion being impeded by anything in the nature of the molecule itself—in its shape, size, or other property. This view is supported, for instance, by the fact that a gas will diffuse or spread out into space indefinitely (practically) if not confined in a retaining vessel, which neither a liquid nor a solid can do without first passing into the gaseous state; and by the further fact that when the volume is forcibly made small or the gas put under great pressure, whereby the molecules are forced together so that presumably the individual motions are affected by the peculiar nature of the molecules, the gas obeys the usual laws governing the volume—pressure—temperature relations less and less accurately. It follows that these volume—pressure—temperature relations are dependent only upon the *number* of molecules involved.

Just so a solute by virtue of the presence of the solvent is supposed to separate into molecules which can move so freely among one another as to be independent of any inherent characteristic of the molecule itself and, consequently, will move or diffuse throughout the solvent until the solution becomes homogeneous. Only, instead of diffusing indefinitely into space, the ultimate volume which the solute may occupy, independent of any containing vessel with semipermeable walls, is the volume of the solution. Therefore, it would be expected that these volume—pressure—temperature relations which hold for gases would also hold for solutes, as it is only the number of molecules of the solute which are involved in determining them and not anything in the nature of the molecule itself. This has been found to be the case exactly, and all the laws governing these relations for gases are also laws for solutes if we substitute the term osmotic pressure for the vapor pressure.

DISSOCIATION OF ELECTROLYTES.

The solutions with which we most commonly meet, and those which will almost exclusively interest us, are those in which the solvent is water and the solute or solutes are salts; that is, substances formed by the action of an acid on a base. These substances, when dissolved, show wide variations from the laws which have just been described. These variations are, perhaps, best studied by a consideration of the osmotic pressures they exert, which are found in all cases to be higher than was to be expected. Furthermore, these pressures vary with temperature or concentration in a way entirely different from solutions in general. It was first pointed out by Arrhenius that these variations are characteristic of solutions of electrolytes; that is, solutions in which the electric current passes. By making use of a hypothesis

hich had been advanced by Clausius the phenomena were readily plicable. Clausius was led to assume that when an electrolyte was solved in water it separated, partially at least, into components or, we now say, dissociates. These dissociated parts are chemical equivents, and in the act of dissociating develop equivalent amounts of ectricity with different signs. Thus sodium chlorid would dissociate to sodium, bearing a certain amount of electricity with the positive gn; and a chemically equivalent amount of chlorine, bearing an ual amount of negative electricity. In the notation of chemistry is is expressed

$$NaCl \gtrless \overset{+}{Na} + \overset{-}{Cl}$$

In an exactly similar manner sodium sulphate would dissociate as hus indicated:

$$Na_2SO_4 \gtrless \overset{+}{Na} + \overset{+}{Na} + \overset{-}{SO_4}$$

the negative electricity on the group SO_4, or sulphion exactly equaling the positive electricity on the two sodium equivalents.

Borrowing an expression introduced by Faraday, these dissociated parts *with their electric charges* are called *ions*. When the solution containing ions is put in an electric circuit, the ions bearing the positive charges are attracted to the negative pole of the circuit and the ions bearing the negative charges toward the positive pole, in accordance with the well known law of electricity.

Retaining sodium chlorid as an example, we may illustrate the phenomena by a mechanical analogy, thus:

	Positive pole.	−	−			+	+	Negative pole.	
+		Cl....Cl.....ClNa		ClNa.....Na....Na					−
		−	−			+	+		
		Cl....Cl.....ClNa		ClNa.....Na....Na					
		−	−			+	+		
		Cl....Cl.....ClNa		ClNa.....Na....Na					

The chlorine ions on arriving at the positive pole give up their electric charges, thus becoming ordinary chlorine, which escapes as the well-known gas or reacts on the water of the solvent to form hydrochloric acid and oxygen, which escapes as a gas. In a similar manner the sodium ions discharge their electric burdens, thereby becoming ordinary sodium, and immediately react on the water to form sodium hydrate and hydrogen. It is to be observed, however, that the chemical behavior of the ions is entirely different from what it becomes when their electric charges have been lost. The illustration just used indicates that there would be a gradual accumulation of hydrochloric acid at the positive pole and of sodium hydrate at the negative pole. This is what actually happens, as anyone can readily test by drawing off portions of the solution near the poles and analyzing them.

Each of these ions in solution behaves to all intents and purpos as an individual molecule and exerts its influence as such in deter ing the osmotic pressure in the solution.

Without going into details, it may be said that from an estimat of the osmotic pressure it is possible to determine the number of io in a given solution. From the conductivity it is also possible to det mine the number of ions; and the agreement by both of these metho is of such a character as to make this idea of electrolytic dissociati or ionization one of the best established working hypotheses scien now possesses.

REVERSIBLE REACTIONS AND THE MASS LAW.

Suppose a solution of a salt, for example sodium chlorid, be brough in contact with another salt, such as potassium nitrate. There wi then be in the solution not only the sodium chlorid and the potassium nitrate, but the ions formed from them, which may be represented thus:

$$NaCl,\ KNO_3,\ \overset{+}{Na},\ \overset{+}{K},\ \overset{-}{Cl},\ \text{and}\ \overset{-}{NO_3}.$$

But the $\overset{+}{Na}$ ions and $\overset{-}{NO_3}$ ions can form sodium nitrate and will form it to a certain extent, so that we shall have this salt also in the solution. In the same way potassium chlorid will be formed and the final stat of the solution will represent an equilibrium between the solvent wate and the various salts and ions which can be formed. It is obvious tha the same condition could be obtained by starting with sodium nitrat and potassium chlorid; and the equilibrium could be displaced one way or the other by varying any of the constituents. Such a reaction i called *reversible*. Again, sodium chlorid in water partially dissociate thus:

$$NaCl \lesssim \overset{+}{Na},\ \overset{-}{Cl}$$

But if the concentration be altered by the addition or evaporation of water, the equilibrium is displaced and either more sodium chlorid will dissociate or more will be formed from the already dissociated ions. In fact, practically all simple reactions so far studied, whether in solution or otherwise, have been found to be reversible.

Suppose a reversible reaction between A and B with the formation of C and D. It may be expressed thus:

$$A+B \lesssim C+D$$

Let p, q, r, s represent the active masses or the number of molecules per unit volume acting, respectively.

Let K be the rate of combination of unit masses of A and B to form C and D, and

Let K_1 be the rate of combination of unit masses of C and D to form A and B.

The magnitude of the reaction $A+B \rightarrow .$ is Kpq, for it is directly proportional to the rate of combination and to the active masses, and it will be K_1rs for the reaction $C+D \rightarrow .$ Therefore when equilibrium is established

$$Kpq = K_1rs. \qquad (1)$$

This is known as the law of "mass action," or of Guldberg and Waage. It is conventional to take as the unit of active mass in solutions one reacting weight per liter.

Applying this formula to the case just cited,

$$NaCl \leftrightarrows \overset{-}{Na} + \overset{+}{Cl},$$

we would have

$$K_1pq = K_2r,$$

where p represents the concentration of the ion $\overset{-}{Na}$, q that of the ion $\overset{+}{Cl}$, and r that of the undissociated salt NaCl. From which

$$\frac{pq}{r} = \frac{K_2}{K_1} = K_i \qquad (2)$$

which is known as the dissociation or ionization constant, and is a constant for constant pressure and temperature, but is different for different salts.

For those acids and bases and their salts which are usually characterized as strong K_i is found to be large, while on the contrary it is always small for the so-called weak acids, bases, and their salts. Since it is obvious that it is the active masses of the ions which make an acid or base weak or strong, the magnitude of K_i is generally taken as the measure of the relative "strength" of an acid or base at the present time.

Still applying formula (2) to such a case as

$$NaCl \rightleftarrows \overset{-}{Na} + \overset{+}{Cl}$$

we see that for every $\overset{-}{Na}$ ion there will be a $\overset{+}{Cl}$ ion—that is, the concentration or active mass will be the same, and

$$\frac{p^2}{r} = K \text{ or } p^2 = Kr$$

therefore the concentration of the undissociated salt is proportional to the square of the concentration of the dissociated salt. From which it follows that the greater the dilution the greater the proportion of dissociated to undissociated salt.

HETEROGENEOUS EQUILIBRIA.

So far we have considered only cases of homogeneous equilibrium, where we had but one reversible reaction and complete solution. But there are certain types of heterogeneous equilibrium which remain to be considered.

Suppose a salt S in contact with a solution saturated with respect to it and containing therefore S^1 of it. S^1 will be partially dissociated into A and B. Let c be the concentration of the undissolved salt, c_1 the concentration of the dissolved but undissociated salt, and a and b the concentrations, respectively, for the ions. When equilibrium shall have been established between $S \rightleftarrows S^1$ the equation expressing the fact will be

$$\frac{c}{c_1} = K_1 \tag{3}$$

but c, the concentration of the undissolved substance, is the same thing as its specific gravity—that is, a constant K_2; therefore

$$c_1 = \frac{K_2}{K_1} = K_3 \tag{4}$$

From the dissolved salt we get $S^1 \rightleftarrows A + B$ and

$$\frac{ab}{c_1} = K_4 \tag{5}$$

from which, substituting from (4),

$$ab = K_3 K_4 \text{ or } K_s \tag{6}$$

which is known as the solubility constant.

If the equilibrium remain undisturbed, this equation (6) will hold, but if it be disturbed there will be two possibilities, either ab is greater than K ($ab > K$) or ab is less than K ($ab < K$). If $ab > K$, then the reaction will go $A + B \rightarrow S^1$ and $S^1 \rightarrow S$, and there will be a precipitation of the salt. If $ab < K$, the reaction will go $S \rightarrow S^1$ and $S^1 \rightarrow A + B$, and there will be a further solution of S.

If we have two or more salts brought into solution in water, as was indicated above, there will be formed also all the possible combinations of which the dissociated ions are capable, as well as the ions themselves, and of all these possible combinations that one will be the first to precipitate the product of whose ionic concentrations shall first exceed its solubility constant. Suppose, for example, that to a solution containing sodium chlorid NaCl and its ions $\overset{+}{Na}$ and $\overset{-}{Cl}$ we add potassium chlorid which will yield its ions $\overset{+}{K}$ and $\overset{-}{Cl}$, one of which is common to the salt already in solution. Then the product of the ionic concentrations of both salts is thereby increased. It might happen that this product for the salt already in solution was equal to its solubility constant; the increase in the product brought about by the addition of the salt with a common ion will indicate a state of instable equilibrium; there will be a "forcing back of the dissociation" with formation of an excess of undissociated salt and its precipitation from the solution. Thus lead chlorid can be easily precipitated from a solution by the addition of potassium chlorid. By adding strong hydro-

loric acid solution to a moderately concentrated solution of barium lorid one can precipitate the latter in beautiful crystalline scales. very interesting case, illustrating these views, which is to be found nature, has recently come under investigation in this laboratory.

CARBONATES AND LIME IN GREAT SALT LAKE.

The water of the Great Salt Lake in Utah is a strong solution of alts. The most conspicuous base present is sodium, though there are so potassium, magnesium, and a small amount of calcium. There is ason to believe that strontium would be found on a careful examination, but it is present (if at all) in amounts which could easily escape tection without unusual refinement in the analysis. Among the acids present carbonic acid has not been recorded in any analysis of the water so far as I am aware. But its presence has been clearly shown by an examination in this laboratory. While working in the neighborhood of the lake recently it occurred to Mr. Gardner, of this division, to test the alkalinity of the lake water by adding a few drops of alcoholic phenolphthalein solution to a sample. No alkaline reaction could be observed, but on throwing away the tested sample and rinsing the containing vessel with distilled water a distinct pink color, denoting an alkaline reaction, was observed in the wash waters. An examination of the distilled water failed to show any alkalinity and the matter was referred to this laboratory. Samples of the water from the lake were examined and found to show no reaction with phenolphthalein, but on gradually diluting the solution the pink color appeared. Strong artificial brines of sodium chlorid were then prepared and small quantities of sodium carbonate added. These also failed to show any color on the addition of phenolphthalein, but yielded the color on dilution. The reverse experiment was then tried of gradually adding sodium chlorid to a solution containing a small amount of sodium carbonate and colored a strong pink with phenolphthalein. As the concentration of the solution with respect to the sodium chlorid increased, the color gradually disappeared. The explanation of the phenomena was clearly demonstrated. The small amount of carbonate present would be but little dissociated under any circumstances, the carbonates all having a very low ionization constant. But the very large number of sodium ions in the solution derived from great quantities of sodium chlorid and sulphate present, the solution, in fact, practically saturated with respect to them, forced back the dissociation of the weakly dissociating sodium carbonate until there was none of this salt ionized in the solution. Sodium carbonate itself is not capable of an alkaline reaction and its solutions only become so through its ionization products, as will be explained later. In consequence this delicate test for its presence of necessity failed, and the small amount of carbonic acid involved could be very readily overlooked in the analysis, especially when there

was no reason to expect its presence. It may be of interest to n that an examination in this laboratory has shown the amount of sodi carbonate present to be about 0.012 per cent of the solution.

The absence of more than a comparatively insignificant amount lime from the waters of the lake has been the subject of much comme especially as salt lakes in general contain a good deal of lime, so times even an astonishing amount. That calcium salts have b brought into the lake in very considerable quantities there is m abundant evidence in the large amounts of carbonate of lime found the shores and bottom of the lake. But calcium carbonate could n remain in solution in the lake water to any greater extent than a me trace, for it is a very slightly soluble substance in itself and could n be ionized, as we have just seen, since the conditions are impossible f the existence of any carbonic-acid ions. Moreover, the water of th lake contains so much sulphate in solution that it must be regarded a practically saturated with respect to sulphions. Therefore only so muc calcium sulphate can remain in solution as will be soluble without ioniza tion—a comparatively small amount, as is well known. Should there b other calcium salts in the solution they would be continually dissociat ing and forming calcium sulphate and being precipitated from the solu tion until equilibrium should be restored. It should be remembered, however, that the soluble carbonates constantly being brought into the lake will tend to restore the sulphions to the solution, the carbonic-acid ions going out of solution with the lime. Nevertheless, it is the rela tively large amount of sulphates of the alkalis present which must be regarded as the controlling factor in the small amount of lime soluble in the waters of the lake.

TWO OR MORE SOLUTES WITH NO COMMON ION.

Suppose, on the other hand, that to a solution containing an electrolyte another containing no common ion be added. As has been already illustrated, there will be at once the formation of all the combinations possible to the ions, and with the consequent taking away of the ions for this purpose there will be a lowering of the product of ionic concentration for each of the salts; that is, the solubility will be increased. This phenomenon is most strikingly illustrated in the case of those salts usually regarded as insoluble. For instance, gypsum, which is essentially the salt calcium sulphate containing some water, is sparingly soluble in water. But the addition of an electrolyte with no common ion, such as sodium chlorid, will considerably increase the solubility of the gypsum. Some experiments made in this laboratory have shown that in moderately strong brines containing only sodium chlorid gypsum can be regarded as a soluble salt. The reason for this is readily seen when the substances which are formed are considered, both the calcium chlorid and the sodium sulphate being very soluble salts. The transportation of large quantities of lime by the drainage and

pund waters in arid regions where these salts are found is readily plicable from this point of view.

Calcium carbonate, so abundant and so important in nature, is dis-lved in a precisely similar way; but the ionization of carbonates ing relatively small, the effect is not so striking and relatively much s lime is transported in the solution. Treadwell and Reuter[1] have ently published investigations on this point and find the solubility calcium carbonate in sodium chlorid solutions does not become rkedly large until considerable concentrations of the latter salt are ched. The effect of carbon dioxid in forming the more soluble bicar-nate of lime undoubtedly is an important element in this connection, t as the ionization is but little affected by its presence its influence st be small in the presence of such a salt as sodium chlorid.

HYDROLYSIS.

Water is itself a very weak acid with a very low ionization constant, t it does dissociate to a limited extent into hydrogen and hydroxyl ns, thus:

$$H_2O \rightleftarrows \overset{+}{H} + \overset{-}{OH}.$$

The absolute amount of this dissociation is very small, but it has been the subject of the most careful and painstaking investigation. From the work of Kohlrausch, Ostwald, Arrhenius, and Weis it would appear that absolutely pure water would contain certainly less than 1 gram of hydrogen ions in 12,000,000 liters of water, but nevertheless there would always be some present. These dissociated ions from water will of course react with the ions of the dissolved electrolyte, thus:

$$NaCl + HOH \rightleftarrows NaOH + HCl,$$

but the ionization constants of the sodium hydrate and the hydrochloric acid are very large, while that of water is relatively very small indeed, so that the latter will be formed and precipitated as such nearly completely, and the total effect will be so small as to be incapable of detection by ordinary methods. This will be true for any electrolyte with high ionization constant, but with an electrolyte which ionizes to a small degree the effect becomes important. For instance, sodium carbonate has a very low ionization constant in water. The reaction is indicated thus:

$$Na_2CO_3 + HOH \rightleftarrows Na\,OH + HNaCO_3,$$

and while the acid sodium carbonate does dissociate further it is to a very slight extent, as is the dissociation of the sodium carbonate and water as compared with the dissociation or ionization of the sodium hydrate; in consequence, the solution behaves as though it were, as in

[1] Zeit. Anorg. Chem., 17; 170 (1898).

fact it is, a solution of sodium hydroxid. This phenomenon of t dissociation of the salt of a weak acid or a weak base in water, w the formation of the corresponding strong base or acid possible, h been called *hydrolization*. The ionization of water is increased b heating, a fact of importance in many analytical operations. It c be very beautifully illustrated with calcium carbonate. If powder marble be shaken up with water it dissolves to a very slight exte and is hydrolized with the formation of calcium hydrate, which c be shown by the alkaline reaction with a few drops of phenolphthalei On heating the color becomes very greatly intensified, but on coolin it gradually returns to its former condition. This increased hydrolyt power of heated waters is obviously of the first importance in studyin geological problems involving the solution of such weak salts as ca bonates, silicates, aluminates, borates, etc., but its full significance ca hardly be said to be appreciated as yet.

HILGARD ON THE RÔLE OF CARBON DIOXID.

The importance of these relations in studying soil conditions and drainage waters, especially in arid regions where soluble salts abound, has not been without some recognition. Hilgard, with Weber,[1] and later with Jaffa,[2] has given the subject a good deal of attention and has formulated an hypothesis to account for facts observed. The importance of the subject and the authority which attaches to the views of this investigator both call for a somewhat detailed examination of the hypothesis.

From long observation Hilgard was impressed by the very great frequency of the occurrence of gypsum in alkaline waters and soil leachings, even when considerable quantities of soluble alkaline carbonates were present and when, a priori, the precipitation of all (practically) of the calcium in the gypsum as insoluble calcium carbonate might be expected.

On looking over the literature he found a few sporadic references pertaining to the subject, wherein no explanation is advanced, or the phenomena are ascribed to some peculiar solvent action of the salts, without, however, any hypothesis as to the nature of this reaction.

These solutions containing the gypsum or in contact with it are always alkaline, but on being evaporated to dryness or to relatively high concentration, this alkalinity is diminished and a greater or less amount of the calcium of the gypsum is precipitated as the ordinary carbonate.

Considering the origin of these solutions, Hilgard is led to the view that the unlooked-for phenomena presented are due to the presence of an excess of carbonic acid in the waters or soil leachings, and points

[1] Proceedings of the Society for the Promotion of Agricultural Science, 1888, p. 40.
[2] Ibid, 1890, p. 80.

; the great probability of its presence. This view was tested by sing carbon dioxid, for various periods of time from ten minutes to) hours, into solutions of alkaline sulphates and chlorids, at the ordi- y room temperature, in which precipitated calcium carbonate was pended. Taking care to avoid the first masking of the reaction, ich sometimes occurred from the large excess of carbon dioxid, in all es the solutions were found to have become alkaline and, on the lition of alcohol to the solution, a precipitate was thrown down in ich gypsum and calcium carbonate could both be readily recognized. ogether with Weber he then undertook some quantitative measure- nts. He made up solutions containing from 0.25 grams to 2 grams assium sulphate per liter. In these solutions he suspended calcium bonate and kept the solutions agitated while passing in carbon dioxid 40 minutes. The solutions were kept at 18° during the experiment l a little litmus was added. At first the solution would redden, ing to the action of the carbonic acid on the litmus, but in about ten nutes it would become blue, the color intensifying as the reaction gressed. At the end, aliquot portions were filtered and tested as lows:

I. The "total alkalinity" was determined by titrating with normal lphuric acid (alkalinity=No. of cc's of the normal acid required).

II. The portion was completely evaporated and dried at 110°, then ached, and the alkalinity of the leachings determined by titration th normal sulphuric acid.

III. To this portion alcohol was added to make about a 60 per cent ohol solution, whereupon a gelatinous precipitate settled, which, after elve hours' standing, had separated into easily recognized crystals gypsum and calcium carbonate.

From the figures obtained it was concluded that to a point somewhere tween the solutions containing one-half gram and 1 gram per liter of tassium sulphate the reaction was complete as to the replacement of the

lphion by the CO_3-ion, but beyond this the replacement was less com- lete and the relative amount of the replacement was a regular func- on of the initial concentration; further, that the solutions did not cessarily become saturated with respect to acid calcium carbonate, or ie composition of the residue affect the alkalinity.

The further discussion by Hilgard, while interesting in itself, is not portant for our purposes, and the examination of his views may fairly e undertaken with this statement of them.

It should be remembered that calcium carbonate is itself soluble to me extent and hydrolized, as has been indicated on page 18, thus:

$$CaCO_3 + HOH \rightleftarrows Ca(OH)_2 + CaH_2(CO_3)_2$$

nd the solution behaves as a very weak solution of the calcium ydrate, itself but a slightly soluble substance, but distinctly alkaline oward indicators.

When the potassium sulphate is brought into the solution, the s bility of the calcium carbonate is materially increased, since the amo of the calcium that can be held in solution as calcium sulphat decidedly greater, and the equivalent amount of carbonic acid is n in the form of the very soluble salt, potassium carbonate, thus:

$$K_2SO_4 + CaCO_3 \rightleftarrows K_2CO_3 + CaSO_4$$

and the potassium carbonate formed being at once hydrolized for t reasons already given,

$$K_2CO_3 + HOH \rightleftarrows HKCO_3 + KOH,$$

whereby we have the very soluble and highly ionized potassiu hydrate and a characteristic strong alkaline reaction.

It should be borne in mind in experimenting that even with the mo finely divided calcium carbonate some little time is required for th solution to come to equilibrium and this full effect to become observ able.

If carbon dioxid be now passed into the solution, that is to say, car bonic acid be dissolved therein, at least two effects must be considered. It will tend to decrease the solubility of both the calcium carbonate and the potassium carbonate by driving back the dissociation, supposing, of course, that it is present in excess. But as the dissociation of these salts is very small, this effect of its presence will not be appreciable, for its other result will be the formation of bicarbonate of both calcium and potassium, thereby increasing the solubility of the calcium and increasing the amount of this metal in the solution. The potassium bicarbonate is less soluble than the carbonate, but both salts are so soluble that this is no factor in the case before us.

In spite of a widespread impression to the contrary, acid potassium carbonate has been clearly shown to be neutral and not alkaline in its reaction. This fact has been confirmed and most clearly demonstrated by recent work in this laboratory. But it has also been shown that it is a very instable compound, especially when in solution, quickly inverting with the formation of the normal alkaline carbonate, even though some carbon dioxide must be present. It is this inverted normal carbonate which in turn is hydrolized with the formation of potassium hydrate, which gives the solution its alkalinity.

The solution, after the treatment described, will then contain calcium sulphate, potassium sulphate, calcium carbonate or bicarbonate, potassium bicarbonate, and potassium carbonate hydrolized, and these constituents are in such proportions that stable equilibrium exists. As evaporation proceeds this equilibrium is disturbed and the relative proportions vary, accompanied finally with successive separations of these various salts in the solid form. But always, up to complete desiccation, there will theoretically, at least, be *some* of each of these salts in the solution in equilibrium with the others, though the absolute amount of any of them may, and undoubtedly for some will, become quite small.

e addition of alcohol to the solution, by decreasing the solubility of ne of the constituents, or all of them, will produce analogous results, fering only in the quantitative relations to one another. Thus the ution, it is obvious, must remain alkaline. After desiccation re- lution would restore the original conditions for the same total con- ntration, if other things were equal. But it seems probable, from at we now know, that the solubility of the gypsum is materially ected by drying at 110°, and undoubtedly the acid potassium carbon- e would be, which facts are quite competent to account for Hilgard's sults with the leached residues.

It will be shown later that the method he used for determining the alinity of his solutions gives misleading results, and his conclusions rived therefrom cannot fairly be given more than a qualitative value. e main thesis of the paper, that the carbon dioxid dissolved in the il and other natural waters is the controlling factor, at least in the nse he means it must be regarded as incorrect. The observed phe- omena are readily accounted for in a much more complete way in rms of the conventional theory of solutions, and the presence of the rbon dioxid is an unnecessary, though contributing, cause for the bserved phenomena.

GYPSUM AND AMMONIUM SALTS.

It seems pertinent here to call attention to another reaction which has a widespread application. When ammonium carbonate and gypsum are brought into contact we may indicate the reaction that takes place thus:

$$(NH_4)_2CO_3 + CaSO_4 \rightleftarrows CaCO_3 + (NH_4)_2SO_4,$$

calcium carbonate and ammonium sulphate being formed. This fact is made of use for the preservation of ammonia salts in manure piles by the application of gypsum and, under the conditions that there exist, the reaction probably "runs to an end;" that is, all the calcium is converted into the carbonate. The same reaction results may be assumed for the bicarbonate of ammonium. Unlike the corresponding sodium and potassium salts, ammonium carbonate is quite instable. In water solution it immediately commences to break down, forming the acid or bicarbonate. This transformation is greatly accelerated by heat.

The experiment was made in this laboratory of boiling a solution of ammonium carbonate for about twenty-five minutes, in contact with an excess of pure pulverized gypsum. The solution was then allowed to cool and settle. A major portion of the clear supernatant liquid was evaporated until crystallization. The crystalline mass was identified as ammonium sulphate, and on platinum almost completely volatilized when heated, a very small residue being left which could be recognized as a calcium compound by the flame test.

As some of the ammonium sulphate must always remain in the solution, even to complete dryness, it is obvious that the use of ammonium carbonate solution for the reconversion to carbonates of the alkaline

earths after ignition, is not permissible when the soil contains gyp or similar compounds. In spite of a warning by Hilgard[1] this fact not always recognized and has been the occasion of some annoy experiences.

AMELIORATION OF BLACK ALKALI.

The amelioration of the conditions when "black alkali" exists i subject for grave consideration. A suggestion has been made by H gard which has been found to have great value. It is to apply gyp or land plaster to the soil containing sodium carbonate. The react takes place as here indicated:

$$Na_2CO_3 + CaSO_4 \rightleftarrows CaCO_3 + Na_2SO_4,$$

the noxious sodium carbonate being to a greater or less extent co verted to less harmful sodium sulphate or "white alkali" and the har less and but slightly soluble carbonate of lime. The solubility of t calcium carbonate being so very small and made even less so by t presence of the more soluble calcium sulphate with a common ion, t tendency of the reaction will be to "run to the end" before equilibriu is established. But to bring about this desired result it is necessar that the soil should be well drained and aerated, partly, in order t carry off the soluble salts; and this may well be of considerable impor tance, for there is evidence for the opinion that soils show a selectiv absorption or adsorption, and recent work of Mr. L. J. Briggs, of thi division, indicates that sodium sulphate is much more readily leached from a soil than sodium carbonate. But more especially because in the presence of water and in a soil which is not well aerated there exists a condition favorable to the conserving of carbonic acid in the soil and, under the influence of this agent, the calcium carbonate is converted into the acid carbonate, its solubility much increased, and therefore its active mass, with the result that a reaction opposite to the one just indicated will prevail. Thus

$$CaCO_3 + H_2CO_3 \rightleftarrows CaH_2(CO_3)_2,$$

and

$$Na_2SO_4 + CaH_2(CO_3)_2 \rightleftarrows CaSO_4 + NaHCO_3,$$

but the acid sodium carbonate formed, as will be shown, is instable in solution and at once inverts with the formation of the undesirable sodium carbonate, even when some carbonic acid must be present.

$$NaHCO_3 \rightleftarrows Na_2CO_3 + H_2O + CO_2$$

Empirically these controlling conditions were determined, and pointed out by Hilgard. A correct understanding of their influence and importance must prove of use in their management.

[1] Loc. cit., 1888, p. 40.

ANALYTICAL PROBLEMS.

The preparation of a sample of soil or soil crust containing large amounts of these soluble salts presents peculiar difficulties. The problem is not the complete chemical analysis of the specimens. This would require the easy application of familiar conventional methods. What is desired is information as to the portion of the sample which is soluble in water. The total amount present in solution in water in contact with the soil can be determined in such cases where it may be desired by the investigator in the field, with altogether sufficient accuracy, by means of the well-known electrical instrument designed for this division. The question to be answered in the laboratory is what salts are present and their relative proportions in these soil solutions.

The sample, as it comes to the analyst, is usually a dried portion of the soil or soil crust. Since the total amount of salts present is not desired, any convenient amount may be taken for the analysis. Two modes of procedure suggest themselves:

I. To leach out the soluble constituents. Experience has shown this to be an ineffective method. It has been known since Bronner's work, in 1836, confirmed by the work in Liebig's laboratory, that of Way, and many others since, that soils are peculiarly adapted to the illustration of the little understood phenomena of selective adsorption and desorption. Some little attention has been given to this subject in recent years, principally by Ostwald. But it must be said in all frankness that our knowledge of the matter is in a very unsatisfactory state. Attempts were made to extract some of these soil crusts by throwing them on a filter and extracting with successive portions of water.

The mechanical difficulties in the filtering, the inefficiency of the method, as evidenced by the very considerable amounts of chlorid in the wash water after many extractions, caused this procedure to be abandoned. Some of the same soil crusts were then put in a continuous extraction apparatus which was known to be of a very efficient type. After extraction for three working days of eight hours, it was found that there were yet very large quantities of chlorid in the crust. After seven days' extraction chlorids were still coming through. Considering the nature of the salts present, an application of the laws of solution seemed to cast doubt on the validity of this method, aside from the difficulties just described, so that it has been definitely abandoned in this laboratory. It would seem desirable that a more systematic and careful investigation of the matter should be made, and it is hoped that the subject will appeal to some one whose time and opportunities will permit it.

II. The procedure we follow at present is to take about 20 grams of the sample, if it appears to be largely soil, more or less according to judgment as the proportion of salts varies, and shake up thoroughly

with about 350 cc. of water. This shaking or stirring is repeated f quently for a day. The whole is then allowed to stand overnight a day, as convenience dictates. The supernatant liquid, which usually quite clear, is then decanted through a filter, as much as p sible being poured from the residual mud without actually drainin The filtrate is then made up to about 500 cc. and aliquot porti taken for the analysis according to the conventional method. Cert assumptions are made in this procedure, but they appear warranta It is to be supposed that some of all the salts remain in the resid mud. Gypsum, which is a very common constituent in these sampl undoubtedly fails to be extracted to anything like completeness. Mo over, the solution which is decanted from the soil may well be qu different in concentration from the solutions which would occur in t field, and consequently the proportion of salts dissolved may be dif ent from the larger volume of water used. Taking these facts in consideration, it nevertheless seems probable that the solution as w prepare it gives a *fair approximation* to the soluble constituents of th soil, barring, of course, excessive amounts of such a substance as gy sum, and will give a fair idea of what a drainage water in that s would carry away. We can only say that in the light of our exp rience, and after giving a great deal of consideration to the subject, seems to present fewer objections than any procedure so far suggeste

It sometimes happens that after decanting through the filter th solution will remain more or less cloudy, even after prolonged stand ing. When cloudiness is due to suspended mineral matter, it can gen erally be removed by running the solution a second time through a Schleicher and Schüll "hardened" filter, drying the filter, and washing as quickly as possible with several successive small portions of hot water.

In general what the analyst has to estimate in the solution are the chlorids, sulphates, and carbonates of calcium, magnesium, and sodium. Occasionally other substances, as the salts of potassium and strontium, may be present in sufficient quantity to require their estimation, but this is exceptional; usually they are present in such minute quantities that they may be disregarded. Too little is known, as yet, regarding the nature of the organic matter which may be in the solution, and its effect on the other constituents to make its determination of any value. It is important, however, that a *direct determination* of all the constituents usually found should be made, and it can not be assumed that any one of them, the sodium for instance, can be calculated by difference. If there be organic matter in the solution, an attempt to determine the total mineral constituents will necessitate its burning at a temperature which will inevitably cause a loss in the other constituents. Its oxidation by other methods, while possible, is not justified on account of the time required, and, moreover, either liberates the carbonic acid or presents other chemical objections. The difficulty in

dehydrating a residue, when there will be so much "water of lization," will be sufficiently obvious to any analyst. To attempt ulate the amount of sodium required with the other bases to neutralize the acid found will often yield misleading results there are mixtures of monovalent and bivalent acids. Under circumstances different analysts would get different results, ding upon the way in which the various bases and acids were ed.

statement of the analytical results merits attention. The con- nal method of stating them as salts is often misleading and gen- quite unwarrantable, with our present knowledge. To illustrate, riter had occasion recently to compare the analyses of the mineral ituents of the Great Salt Lake, made through a wide range of time. nalyses were all calculated in the same way, presumably for pur- of comparison, and are stated thus:

	Gale, 1850.	Allen, 1869.	Bassett, 1873.	Talmage.	
				1885.	1889.
chlorid	20.20	11.86	8.85	13.586	15.743
sulphate	1.83	.93	1.09	1.421	1.050
ium chlorid	.25	1.49	1.19	1.129	2.011
m sulphate		.09	.20	.148	.279
ium sulphate		.53		.432	.474
ium chlorid			1.89		
of chlorine		.09	.20		
Total	22.28	14.99	13.42	16.716	19.557

Now the chlorine uncombined, stated in several of these analyses, can be accounted for by recombining the data in a different way than at stated. It is not necessary to go into the details, as it is obviously matter of mere arithmetical jugglery. It will be observed that all e magnesium is stated as having been present as chlorid, whereas it probable that many other analysts, perhaps the majority, would ave calculated it as sulphate. As to which would have been the better ay there can be no dispute. By referring to the discussion in the earlier part of this paper it will be seen that as a matter of fact there must necessarily have been both magnesium chlorid and magnesium sulphate in the solution. In just what proportions they would be it is of course possible to say theoretically, but the practical difficulties in determining this question, in the vast majority of cases, may be regarded as at present entirely too difficult to warrant any attempt to do so. In view of the fact that it is the ions with which we really have to deal in the majority of instances, and that it is in fact the amount of the possible ions which may be formed that we actually estimate in our analyses, it would seem that the time has come when some institution or organization that could speak with authority should inaugurate the convention of stating analyses in this more rational way. The difficulties besetting any individual or sporadic attempts in this direction

are so patent they need no discussion. Yet the need of this reform an intelligent appreciation and use of the material can not be strongly urged.

Since the epoch-making work of Liebig there has been a const effort on the part of chemists to determine the agricultural value o soil by a chemical examination or analysis. The methods which h been suggested all depend upon the principle of bringing the consti ents of the soil into solution to a greater or less extent in the presen of some acid.

The constituents of the soil are for the most part salts. These sa are in general but slightly soluble, it is true, but nevertheless soluble some extent; and consequently in aqueous solutions would be ioniz as other salts are, or, since they are usually salts of weak acids, hydr lized, as has been described elsewhere in this paper. The presence an acid, or, for that matter, any other electrolyte, such as a base or salt, displaces the equilibrium and alters the solubility of the soil con stituents. Acids have met with most favor in this regard, and th reason for this is now apparent, because in dissociating they do no furnish ions common to the dissociating soil constituents, and hen the solubility changes are more marked when they are employed.

It will be readily seen that these acid extracts represent a state equilibrium between the dissociated and undissociated electrolyt contained in the solution. If the acid solution be allowed to remai long enough in contact with the soil, it will become saturated wit respect to the soil constituents or their ions if they are present i sufficient quantity, or will completely dissolve such of these constitu ents as are not present in sufficient quantity to saturate the solven with respect to them; but with salts such as compose the soil th surface exposed as controlling the "active mass," as well as their com paratively small solubility, must be considered, and for a final com plete state of equilibrium to be obtained will require generally that the solvent be kept in contact with the soil for a relatively long time.

It is obvious that in any particular case many factors or conditions enter, and the subject is bewilderingly complex. The temperature as controlling the solubility of the various electrolytes themselves; as controlling the migration velocities of the ions; the concentration of these various electrolytes and their resulting ions; their mutual effect in retarding or increasing solution when they yield a common ion or do not yield a common ion; the surface exposed and the time which it is exposed, must all be considered.

It is not surprising, therefore, that experience has shown different acids to have yielded widely varying results; that the same acid would not always yield comparable results, even when the same concentration was used, for in such a case the factors, common ions, and active mass are incontrollable. The practice finding most favor at the present day is to extract the soil with a hot concentrated aqueous solu-

of hydrochloric acid, but to this procedure there is the objection t the concentration with respect to hydrochloric acid, and therefore active mass of this reagent, is measurably dependent upon the ometric pressure.

The conditions which will determine the equilibria in our acid racts are similar in kind to those which control the equilibria of our l solutions, but they are so utterly incomparable in degree as to ke any attempt at formulating a quantitative comparison well-nigh peless. And when we consider the effect of other phenomena which known to come into play in the soil, such as absorption or selective sorption, for instance, this attempt must be regarded as absolutely peless until we shall have obtained much more and precise knowledge garding these subjects.

FIELD METHOD FOR ESTIMATING SULPHATES, CHLORIDS, AND CARBONATES.

It has often been found desirable in our field work to obtain a knowlge of the relative quantities of the various salts which may be present. eference of samples to the laboratory for analysis by the regular ethods is not practicable, on account of the time involved, it being ecessary that the desired information be obtainable within a few hours the furthest, in order to determine the direction in which the work hand should proceed. To meet these requirements the following cheme has been devised:

The apparatus has been reduced to a minimum; it has been so arranged hat it can be readily carried into the field, and our parties are regularly provided with a small carrying case, in which everything needful n the analysis is securely and neatly packed. It is provided with four r five burettes of 25 cc. capacity, graduated to $\frac{1}{10}$ cc. ($\frac{1}{5}$ cc. will answer every purpose quite as well); several bottles (generally four) holding 250 cc. when filled to mark on the neck; specimen vials and small bottles, to carry reagents—the solid reagents required for the standard solutions are carefully weighed into specimen vials or tubes in the laboratory, and sent out as required, the solutions being made in the field by means of the 250 cc. bottles mentioned; a small porcelain casserole, in which the titrations are made, and which can be heated over any fire—sometimes small Erlenmeyer flasks and a spirit lamp are preferred; and several clamps for fastening the burettes to the side of a wagon.

It is obviously impossible to provide a complete analysis under the conditions prescribed, but for the purpose desired it is sufficient to know the relative amounts of carbonates, sulphates, and chlorids present. Therefore the method is designed to estimate these acids, which for convenience are conventionally expressed in terms of the sodium salt. A sample of water is taken, or an extract is made from the soil, and the solution filtered or decanted. The solution need not be clear.

A known amount of barium nitrate is added in excess to 10 cc. of the extract, to precipitate sulphates and carbonates. The excess of barium nitrate is titrated back with a solution of potassium chromate, using silver nitrate on a porcelain tile or plate as an indicator. In the same vessel standard silver nitrate is run in to precipitate the chlorid, using potassium chromate on the porcelain plate as an indicator. A few drops of nitric acid are added, and the liquid heated to boiling, to drive off the carbon dioxid precipitated with the barium. The excess of nitric acid is neutralized with powdered magnesium carbonate. Again the solution is titrated with potassium chromate, the quantity required indicating the amount of carbonate in the original solution. This, subtracted from the amount required for sulphates and carbonates, indicates the sulphates present in the solution. The three titrations are made in the one vessel, making the method a very rapid and comparatively simple one.

The method is not without its shortcomings, but it is in the nature of things intended only to obtain approximate results and has proven itself well adapted to this purpose. It may well be capable of refinement.

It should be noted that the estimation of the barium by adding potassium chromate, using the silver nitrate as an indicator, can not be advantageously done by adding the silver nitrate to the solution and even on the porcelain plate the reaction is not all that could be desired. The presence of a chlorid in the drop taken for the test necessarily masks the reaction under observation, and even in the absence of chlorids the reaction is not "sharp."

The writer is indebted to Prof. J. D. Tinsley, of New Mexico, for assistance in testing this method, with a view to modifying it for laboratory practice. Without going into details, it may be said at once that the reaction does not appear well adapted to such an application of it. Its use in the field method just described is, however, warranted, considering the nature of the results desired. The scheme, as described, has been found of service for the purposes for which it was designed.

ESTIMATION OF CARBONATES AND BICARBONATES: A FIELD METHOD.

In the course of their survey work in the regions where the "black alkali" exists, our field parties felt the necessity of a rapid method for the estimation of the soluble carbonates in the soil, or really the alkalinity of the soil. They tried at first to meet this want by taking a standard volume of the soil, shaking it up with water and titrating with a standard acid. The results were very soon found to be valueless and the problem was referred to this laboratory as urgent. Obviously, the first thing to do was to study the reaction between an acid and sodium carbonate. It was very soon found that while very good concordant results could be obtained by heating to boiling the solution of sodium carbonate before titrating with standard sulphuric acid solution, that

was far from the case when working in the cold. It ultimately oped that the formation of the acid carbonate or bicarbonate of from the liberated carbonic acid was the cause of the trouble. alt, in spite of a widespread impression to the contrary, is per- neutral toward the usual indicators, but is very instable, and s readily to a greater or less extent, depending on the conditions, normal carbonate which is alkaline in water solutions. In titra- therefore, with a standard acid solution widely varying results been obtained, depending upon the rate at which the solution un in, the temperature, etc.

order to test this reaction more thoroughly a solution of sodium nate was prepared. Fifty cc. of this solution, treated with an excess rium chlorid solution, gave 0.4840 grams of barium carbonate, alent to 0.2601 grams of sodium carbonate. Therefore, 1 cc. of solution contained 0.005202 grams of sodium carbonate, while a normal (N/10) solution should contain 0.00528 grams of the salt. lution of sulphuric acid was made up and, after a number of pre- ary trials to obtain concordant results—without success—a titra- was made in the usual manner, using phenolphthalein as the indi- r and titrating to loss of color, the solution being run in from the ette fairly rapidly. 10 cc. of the sodium carbonate solution was ivalent to 1.38 cc. of the acid solution.

herefore,

c. of the H_2SO_4 solution was equivalent to 7.2 cc. of the Na_2CO_3 solu- on, and

2 cc. of the Na_2CO_3 solution was equal to 0.0374 grams of sodium rbonate.

f the reaction is to be represented thus:

$$Na_2CO_3 + H_2SO_4 = Na_2SO_4 + H_2CO_3,$$

then 0.0374 grams of sodium carbonate should be equivalent to 0.03456 grams of sulphuric acid.

If the reaction is to be represented thus:

$$2\,Na_2CO_3 + H_2SO_4 = 2\,NaHCO_3 + Na_2SO_4,$$

then 0.0374 grams of sodium carbonate should be equivalent to 0.01728 grams of sulphuric acid.

But 50 cc. of the sulphuric acid solution yielded 2.3345 grams of barium sulphate, therefore

1 cc. representing 0.0374 grams sodium carbonate was equivalent to 0.0196 grams of sulphuric acid.

From these results it was concluded that both reactions took place in this case, the latter predominating. Similar results, but different in the quantitative relations, confirmed this general conclusion. The method was therefore abandoned. Various methods were then tried and the

literature thoroughly scanned without finding anything suited to t purpose. Ultimately the following reaction suggested itself:

$$Na_2CO_3+HKSO_4=NaHCO_3+NaKSO_4.$$

Acid potassium sulphate is a well-characterized acid, while both t reaction products are neutral. A tenth normal (N/10) solution of t acid potassium sulphate was prepared and titrated against the sodiu carbonate solution, already described, using phenolphthalein as t indicator. 10 cc. of the sodium carbonate solution required 9.9 cc. the acid potassium in solution, and this result was obtained time a again, only on standing the solutions gradually regained their pin color, due to the inversion of the acid sodium carbonate with the fo mation of the sodium carbonate. While this inversion commenc almost at once, it is not rapid enough to interfere with the titratio This point will be referred to again later in this discussion.

It was proved that the reaction takes place as indicated with quanti tative exactness. The reagent employed is one which can be readil obtained in any desired purity, and is very easy to handle. It remaine to test it for field conditions. A solution of sodium carbonate was pre pared, 10 cc. of which was equivalent to 13.5 cc. of the acid potassiu sulphate solution. 50 cc. of this sodium carbonate solution and 10 gram of a loamy soil were put in a 500 cc. measuring flask, water added t the mark, and the whole vigorously shaken for several minutes. Th solution was then allowed to stand and the soil to partially settle fo five minutes. 100 cc. of the solution was then drawn out with a pipette phenolphthalein solution added, and the turbid solution quickly titrated with the acid potassium sulphate solution, requiring 13.5 cc. This experiment was repeated with identical results.

In order to test the effect of sodium bicarbonate, if present in the soil, as we had reason to suspect was sometimes the case, a solution o this salt was prepared. It partially inverted, and blanks made with it showed that 10 cc. of the solution was equivalent to 0.8 cc. of acid potassium sulphate solution. Ten cubic centimeters of this solution were added to each of two 100 cc. portions of the muddy solution containing sodium carbonate, just described, and they were both titrated at once. They required 14.1 cc. and 14.2 cc. of the acid potassium sulphate solution, respectively, or, subtracting the correction, 0.8 cc. for the bicarbonate, 13.3 cc. and 13.4 cc. Therefore, it may be assumed that the presence of an initial amount of bicarbonate does not affect the reaction materially.

In order to test the method for field use a strong alkali soil, known to contain considerable sodium carbonate, was exactly saturated with water—a process capable of great precision in the amount of water used. Two portions of 20 grams each of the saturated soil, which we will designate as A and A^1, were washed into 500 cc. measuring flasks, water added to mark, and the whole vigorously shaken. They were

owed to stand just five minutes to settle somewhat, and then 100 cc. rtions were drawn off with a pipette for titration. The whole process s then repeated with fresh samples of this same soil, which we will signate as B and C. The number of cubic centimeters of a $\frac{N}{10}$ $HKSO_4$ lution required are here given:

A.	A'.	B.	C.
49.1	50.3	49.1	45.8
48.8	50.0	48.0	50.9
48.6	49.2	49.0	46.3
48.7	49.2	48.8	48.7
Average. 48.8	49.7	48.7	47.9

Under the conditions of the experiment these results may be regarded s quite satisfactory. They were determined by two observers indiscrimiately and as a first test of the method. The particular soil chosen as one which gave a dark gray mud whose color made the end of the itration unusually difficult to determine, and, finally, all these determiations were made in a very bad light. Efforts were next directed to perfecting the mechanical details for field use. It may be said at once hat the method has received a most rigid testing in the field as well s the laboratory, and on solutions of known strength as well as on nknown soils, and has been found to be of easy application and very ccurate. In the absence of any very unusual special condition there is no difficulty to titrating accurately to within 0.1 cc. of the N/10 acid potassium sulphate solution. This would correspond to 0.000528 grams of sodium carbonate. Supposing we started with 20 grams of saturated soil containing 15 grams of solid constitutents and made up the solution to 500 cc., titrating with 100 cc. portions, this would mean an error of 0.017 of 1 per cent. In soils containing from 0.5 per cent to 4 per cent of sodium carbonate this is an accuracy far beyond field requirements. In this laboratory the method is always used in the examination of alkaline soils and waters, and of course with the greatest accuracy that the circumstances will justify. It possesses the inestimable value of showing at once just how much of the sodium carbonate is present as the normal salt, capable of being hydrolized, and acting as an alkali. For this purpose, the usual method of titrating with a standard sulphuric acid solution or of estimating the sodium or carbon dioxid can only be regarded as entirely inadequate and misleading.

The apparatus and procedure finally adopted for the use of our field parties is as follows:

Several (usually four) glass bottles of convenient shape, with cork stoppers, of such a size as to hold 250 cc. of water at 20° C. when filled to a mark on the neck; one or more 25 cc. burettes, graduated to $\frac{1}{10}$ cc. ($\frac{1}{5}$ cc. would amply fill all requirements); a stand or clamp to attach burette to side of wagon or box; one or more 50 cc. pipettes; a vial of

a concentrated alcoholic solution of phenolphthalein; a small v for measuring the soil. This may vary somewhat according to p lections of the user. Before going into the field the weight of a rated soil, the corresponding weight of this same soil when dried at 1 for soils of different textures, which this standard vessel will hold exactly filled, is determined and the results are tabulated in the server's note book. The texture of the soil, and in consequence weights just referred to, can be determined by observation with rem able accuracy after some practice in the field. Small glass vials, containing 1.694 grams of pulverized acid potassium sulphate, carefu weighed and prepared in the laboratory, are carried or sent to the parties as they may need them. This amount of the acid salt wi dissolved in 250 cc. of water gives a N/10 solution, which is usual enough for a large number of determinations. The actual determin tion is made by taking from the cell of the electrical instrument us for determining the total salt content of the soil enough of the saturat soil to just fill the standard vessel. This is then carefully washed in one of the 250 cc. bottles, in which process a small copper funnel is foun very useful. The bottle is then filled to mark, shaken vigorously for few minutes, and allowed to settle for five minutes. Fifty cubic cent meters of the supernatant liquid is drawn off by a pipette and run int a tumbler, Erlenmeyer flask, or any convenient vessel. A few drops o the plenolphthalein solution are added, and if it indicates the presence of an alkali the solution is quickly titrated with the acid potassium sul- phate solution. Supposing the apparatus and solution to have been assembled before starting on the day's work, this whole operation can be readily performed in from ten to twenty minutes, including the noting of the data. As five minutes of this time is available for other purposes, the method is undoubtedly a rapid one, and has proved from actual experience to be far more accurate than our requirements.

In developing this method some observations were made which seem worthy of noting. Calcium carbonate is somewhat soluble in water and is hydrolized so that the solution becomes slightly alkaline. The calcium carbonate is converted into a neutral salt by the acid potas- sium sulphate, so that a false reading may be obtained in estimating the sodium carbonate. In the case of soils or soil crusts this is of no impor- tance, for it takes the calcium carbonate quite a little while to go into solution to a sufficient extent to make this effect noticeable, unless there be another salt such as sodium chlorid or sulphate present, when, as has been pointed out, one is entirely justified in regarding the alka- linity as due to sodium carbonate formed. In testing river or canal waters, however, which show a faint alkalinity, it is well to investigate whether the alkalinity may not be due to calcium carbonate alone. The question can usually be settled at once by testing for the presence of a chlorid or sulphate in the water, in which case when either of these is found the alkalinity may be safely regarded as due to sodium carbonate.

his method can not be considered as available for the reverse pro-re—that is, to run the sodium carbonate from the burette into a tion of the acid potassium sulphate. This would be an advantage ome observers, if it were allowable, because one could then titrate e appearance of color instead of to the disappearance of it. But potassium sulphate must be regarded as a strong acid, quite capable ecomposing carbonates, and by having it in excess, as has just been osed, the acid sodium carbonate which would be first formed would be more or less decomposed by the excess of acid, depending upon temperature and concentration conditions, with the result that the lings obtained would inevitably be nonconcordant and a quantita-interpretation of them would be impossible.

INVERSION OF SODIUM BICARBONATE AND SODIUM BISILICATE.

The fact that acid sodium carbonate, or the bicarbonate, as it is often led, is an instable compound has been alluded to quite frequently this paper. So, when solutions which contained the carbonate have en titrated to absence of color—that is, contain only the acid carbon-e—are allowed to stand they gradually regain color, indicating the version of the bicarbonate and reformation of the carbonate. This as suggested a way of studying this inversion quantitatively, a knowl-dge of which would probably have great practical value as well as heoretical interest. This subject is now under investigation, but only reliminary results have been obtained as yet. It would appear that t the ordinary room temperature (18° C., about) the inversion pro-ceeds quite rapidly, the curve being quite steep until equilibrium is nearly reached, when it suddenly becomes very flat and assumes an assymptotic character.

This reaction has now been very thoroughly tested for both sodium and potassium carbonates, and in the presence of their respective bicarbonates has proved itself most satisfactory. Among the applications of it which have suggested themselves is its use as a method for estimating the relative amounts of the carbonate and bicarbonate in the manufacture of soda and potash, for which up to the present time no satisfactory method has been found. It remains only to say a word as to the indicators. Other indicators have been successfully used, but phenolphthalein has proved by far the most satisfactory for the "sharpness" of the end reaction, the intensity of the color, and because one is not bothered by any change of color with mixed results, the color being entirely absent the instant the sodium carbonate ceases to exist as such.

It has been suggested that carbonates and bicarbonates can be estimated in the same solution by using phenolphthalein as the indicator for the normal carbonates and as soon as color disappears, methyl orange, which is a stronger acid than carbonic acid, being added and the titration continued. Serious objections have been made to this

waters. This soil, as can be readily seen under the microscope, contains a large proportion of unaltered mineral fragments, rich in and alumina and therefore well adapted to yielding these mat under the influence of the solvent action of the water; and, as a m of fact, this packed material is found to rapidly become cemented iron and alumina, as an examination in this laboratory showed. It be regretted that at the time this examination was in progress it not deemed expedient to determine what constituents the irriga water held which might augment its solvent power.

That other agencies are at work in the production of these phen ena may well be the case. For instance, oxidations undoubtedly h a significant rôle in this connection in breaking up the original min als. But it seems equally certain that the part that solutions play h not been given the consideration that it merits, mainly because soluti phenomena have not been understood until comparatively recent ye

The study of hardpan formation necessitates a consideration of c tain physical phenomena; for instance, the movement of water a various solutions in the soil. This subject is receiving attention in t laboratory; but while a good many observations have been made an much valuable data collected, it is yet too soon to formulate a comple hypothesis for this subject. The views here described are put forwa in the hope of furnishing an incentive to more widespread interest an work on this important subject.

THE RÔLE OF FERTILIZERS.

In the action of fertilizers on the soils there is very much to be learned; for, in spite of the great amount of attention that has been given to this important subject, it can not fairly be claimed that we have made much more than a beginning. While it has long been acknowledged that the disintegration of the mineral constituents of the soil, through the agency of the fertilizer, is a factor in its use, and that solution phenomena are important in this connection, but very little advance has been made in this direction, and its full importance has not been appreciated. It can not fail to be of advantage to investigators in this field to give this point of view more consideration in the future; for it is indisputable that the mineral constituents of the soil are salts soluble to at least some extent, and affected in their solubility, as are other salts, by the presence and nature of other solutes in the soil solutions. It becomes of the first importance, therefore, in determining the use of any particular fertilizer to consider its probable conduct on contact with water—what ions it will yield, if it be an electrolyte, and how these ions will affect the solubility of the soil ingredients, and thus bring into activity products which may be of value as plant nutrients. No less desirable is information of this character than is that of the physical effect as modifying the texture or moisture content, for example, or in forming new compounds more or

s desirable; and in the study of this latter point the ideas here sug-ted will be found to have much use. That they will lead to further rk on the purely physical side of the problem is not the least of the vantages in their consideration; for it does not seem too much to pe that the near future will bring us most helpful and practical infor-ıtion as to selective absorption of solutes by soils and as to the ange of vapor pressure in soil solutions, important as modifying the isture content of the air in contact with the soil. Other questions a kindred nature will suggest themselves, and the time is ripe for a ger, broader and more scientific attack on these important problems agriculture.

SUMMARY.

In this paper there have been presented:

1. An outline of the theory of solutions, showing that a solute by rtue of the presence of the solvent behaves as though it were a gas, ıd that electrolytes present the added phenomena of electrolytic ssociation or ionization.

2. A demonstration that the reactions under investigation are of a versible type, and in consequence the Mass law is applicable to a ıdy of the equilibria among the solutes.

3. An application of these views, showing how the solubilities of the ılphate and carbonate of lime in nature are increased by the presence f a solute which dissociates but yields no common ion.

4. An announcement of the presence of sodium carbonate in the waters f the Great Salt Lake, Utah, and an explanation of why this fact has reviously escaped observation, based on the relation which obtains etween the ionization products and the solution constant. A similar xplanation is offered for the scant amount of lime in the waters of this ake.

5. An examination of the hypothesis of Hilgard as to the rôle of arbon dioxid in the genesis of alkali, in which it is demonstrated that he phenomena observed are more satisfactorily accounted for in terms f the theory of solution, and that the carbon dioxid must be regarded s a contributing cause, but not a necessary one.

6. An examination of the Hilgard method for the reclamation of black ılkali soils, with an explanation of the reactions observed and of the mportance of the controlling conditions respecting drainage and the ccumulation of carbon dioxid, empirically announced by Hilgard.

7. An examination of the reaction between calcium sulphate and the arbonates of ammonium. The use of gypsum for conserving ammonia in manure piles is explained. Some errors, with the reasons therefor, which may accompany the use of ammonium carbonate in analytical operations involving salts of the alkaline earths are pointed out.

8. A discussion of some analytical problems in a chemical examina-tion of alkali soils. The nature of the problems is made clear. The

relative merits of leaching the soils and taking a solution in cont with the soil in preparing the sample are discussed, and the adv tages in favor of the latter procedure indicated. The necessity of m ing a direct estimation of each constituent is demonstrated.

9. A plea for the rational statement of analytical data, inasmuch a is the ions which are determined and not the salts. Furthermore, i the ions with which we are generally concerned in the study of a particular problem.

10. A field method for the estimation of sulphates, chlorids, and c bonates, involving three titrations which may all be made on the sa sample in one vessel. Its use in reconnoissance work is described.

11. A rapid method for the estimation of sodium carbonate in t presence of the bicarbonate, depending on the conversion of the alk line carbonate to the neutral acid carbonate, with the formation of neutral sulphate by the addition of acid potassium sulphate. The use the method in the laboratory and in the field is described, and its pro able availability for technical work is suggested. The objections to t use of sulphuric acid in determining "alkalinity" are made evident.

12. Observations on the hydrolysis of sodium carbonate and sodi silicate and the inversion of sodium bicarbonate and sodium bisilica to the normal salts are described briefly.

13. A discussion on the formation of hardpan and similar deposit in which it is pointed out that the hydrolysis of the salts of weak miner acids and subsequent desiccation and deposition of the solution product must be taken into account in any hypothesis as to their genesis.

14. An explanation of the solution and hydrolysis of certain mineral and the consequent alkalinity they display.

15. Suggestions for the study of the functions of fertilizers, in whic the importance of considering the solution phenomena which the presence may effect in the ground waters is made evident.

16. Some observations on selective absorption and other physico chemical phenomena which are incidental to a complete study of th properties of a soil.

SOME NECESSARY MODIFICATIONS IN METHODS OF MECHANICAL ANALYSIS AS APPLIED TO ALKALI SOILS.

By LYMAN J. BRIGGS.

INTRODUCTION.

Many alkali soils present peculiarities in composition which do not permit the use of the ordinary methods of determining their mechanical composition. It consequently seems desirable to call attention to certain modifications in the methods of examination which have been found useful in determining the mechanical composition of samples of alkali soils collected by the field parties of this division.

The following points will be considered:

(1) The disintegration of the soil during the progress of the analysis, resulting from the solvent action of the water used in making the mechanical separation.

(2) Apparatus and method for examining soils subject to excessive disintegration during mechanical analysis, and the advantages of the centrifugal method as applied to all soils.

(3) The treatment of the mechanical separations after ignition to convert the oxides of the alkaline earths into carbonates.

(4) The determination of the water-soluble salt content of soils in connection with their mechanical analyses.

MECHANICAL ANALYSIS OF SOILS SUBJECT TO EXCESSIVE DISINTEGRATION.

Many of the soils of regions requiring irrigation contain considerable amounts of gypsum ($CaSO_4+2H_2O$) and calcium carbonate. In many cases these substances will be found cementing together a number of soil particles, forming an aggregate grain of considerable size. These soils in consequence generally have a somewhat open structure, similar to that of a fine sand, through which water moves rapidly.

When these soils are placed in a considerable quantity of water, as in the beaker method of elutriation, this cementing material dissolves sufficiently to break up the aggregate and release the smaller particles, thus materially changing the nature of the soil. This is most marked

in the case of the gypsum soils on account of the greater solubility of this cement. The solubility of such a cement is considerably increased by the presence of other salts in solution which have no ion in common with those of the cementing material. The dissociated salts react with the calcium sulphate or calcium carbonate in solution to form, to a greater or less extent, all the chemical compounds possible through the rearrangement of the ions of the original substances. As a consequence, more of the cementing material goes into solution and the reactions continue until a condition of equilibrium has been reached. The equilibrium is, of course, disturbed by the addition of water or by changes in temperature. A more detailed statement of these mass reactions will be found in an accompanying paper by Dr. F. K. Cameron.

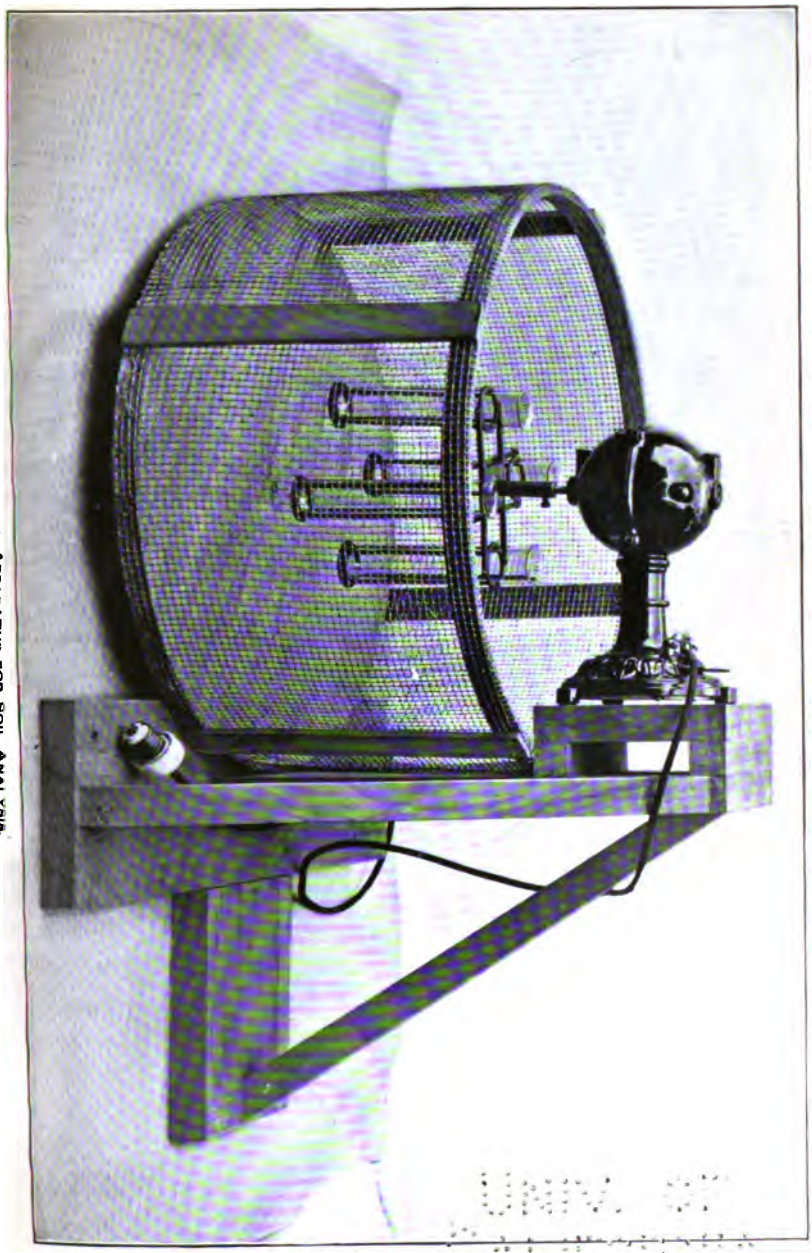
From these considerations it becomes evident that neither the Osborne beaker method nor the elutriator method of Hilgard, both of which require large amounts of water, is applicable to the mechanical analysis of such soils. A trial of the beaker method on a gypsum soil from New Mexico confirmed these conclusions, fresh amounts of "clay" being liberated after each successive addition of distilled water. The determinations by this method differed widely, the amount of finer material increasing with the time employed in the separations. In fact, the amount of "clay" obtained when the soil was allowed to stand in contact with water for some time was sufficient to indicate a soil of close structure, permitting water to pass very slowly, instead of the open, porous structure which the soil was known to possess.

It becomes evident that in order to get an analysis which would fairly represent field conditions it is necessary to make the analysis as rapidly as possible and with the use of a minimum amount of water. For this purpose the centrifugal method has been used with satisfactory results. The small amount of water required and the rapidity with which the separations can be effected tend to reduce materially the amount of gypsum going into solution. The composition of the gypsum soil, as determined by this method, shows a much smaller quantity of clay and a proportionally larger amount of larger particles. This undoubtedly represents much more nearly the mechanical composition of the soil *in situ*. The mechanical composition of such soils must be, at best, somewhat indeterminate, owing to the fact that so large a percentage of the soil consists of water-soluble material.

THE CENTRIFUGAL METHOD.

The use of centrifugal force to hasten the deposition of particles in suspension naturally suggests itself as a means of shortening the tedious process of making separations by the method of sedimentation. Hopkins[1] appears to have been the first to describe this method in detail,

[1] Proceedings of the Fifteenth Annual Convention of the Association of Official Agricultural Chemists, Bulletin 56, Division of Chemistry, U. S. Department of Agriculture, 1898, page 67.



CENTRIFUGAL APPARATUS FOR SOIL ANALYSIS.

ough the device had been previously used by several soil investi-
ors. The method has been found so satisfactory in this laboratory
account of its quickness and convenience and its applicability to all
s that it is believed that a description of the apparatus and the
thod of operation will prove of interest.

he apparatus necessary for making analyses by the centrifugal
thod is inexpensive and simple in construction. The primary requi-
is some means of securing the necessarily high velocity required for
owing down the soil particles from suspension. An electric motor
ost suitable for this purpose if an electric-lighting current is avail-
e. A water motor can be used, although subject to annoying inter-
tions and fluctuations in speed unless an independent water supply
be obtained. Some form of centrifugal apparatus operated by hand
be employed where but few samples are to be analyzed, although
s method will be found to lack the advantage arising from an appa-
tus operated at a constant speed, such as may be obtained by the
e of an electric motor.

The centrifugal apparatus as designed by the writer for making
echanical analyses in the Division of Soils is illustrated in Pl. XXVIII.
ie power is obtained from a Holtzer-Cabot, 110-volt, 16-inch fan motor.
his motor uses a current a little in excess of that required for an
dinary 16-candlepower lamp, and will carry 4 centrifugal tubes of
ie dimensions described without serious heating. This style of motor
supplied with a rheostat in its base, enabling four different speeds
be obtained, which is a great advantage in making separations,
esides enabling the motor to be gradually brought up to speed. The
heostat is also provided with an open contact point for stopping the
otor.

The fan and fan guard being removed, the motor is firmly screwed to
rigid supporting frame with its armature shaft vertical. A second
ollow shaft, milled to fit the armature shaft, is slipped over the latter
nd fastened by a set screw. To the lower end of the hollow shaft are
astened four horizontal arms, each being about 8 cm. long and consist-
ng of two parallel bars of 5 mm. square brass, 4½ cm. apart A brass
ing 5 mm. thick is trunnioned between each pair of bars at their free
ends, and four light brass rods extend downward from this ring to a
similar ring 15 cm. below. This trunnioned system swings outward
and upward in the well-known way when the motor gathers speed. It is
important that the system should swing freely, and care should be taken
that the trunnion screws are sufficiently massive to stand the strain to
which they are subjected at high velocities.

Large heavy test tubes (18 by 3 cm.) serve admirably for the centrif-
ugal tubes. The aperture in the upper metal ring is made large enough
to admit the test tube easily, while the opening in the lower ring is
somewhat smaller and provided with leather or cork washers, on which
the test tube rests. A guard consisting of a screen of 5 mm. mesh

surrounds the movable portion of the apparatus as a safeguard against accidents. To protect the motor, the wires leading from the lighting current should contain fuses which will melt for currents exceeding two or three amperes.

The analyses of four samples may readily be carried on at the same time. Ten grams constitute a suitable sample for analysis in an apparatus of the dimensions described. The preliminary preparation consists in agitating the sample of soil with about 200 cm. of water in a mechanical shaker[1] from six to eight hours, or until the surface of the larger grains, as seen under the microscope, appear to be clean and free from clay particles.

A portion of the contents of each shaker bottle is transferred to its corresponding centrifugal tube. The apparatus is then rotated for a length of time sufficient to throw down from suspension all particles larger than those which it is desired to retain in the finest separation. The "clay" water is then decanted into beakers and the remainder of the contents of the shaker bottles transferred to the tubes, the heavier material being thrown down as before. An important feature of the operation now claims consideration. In making additions of distilled water to the tubes to effect further separations of "clay," it is desirable and important that this water should be forced in under considerable pressure. This forms the most satisfactory and convenient means of getting the material from the bottom of the tube into suspension again, being far superior to any agitation with a stirring rod or a rubber pestle, since it avoids any abrasion and the necessity of washing off the stirring rod each time. It will be found that thorough stirring of the material in the bottom of the tube by the jet of distilled water each time a decantation is made will materially shorten the time and diminish the amount of water required for an analysis. The apparatus for securing this pressure will be referred to later.

When the "clay" has all been separated, as determined by a microscopic examination, using a micrometer, the tubes should be rotated for a shorter time, or at a lower rate of speed, leaving the particles constituting the next separation in suspension. The water containing these particles is then decanted into separate beakers and the process repeated until the separation of the second grade is effected.

In making separations of particles exceeding 0.01 mm. in diameter, the sedimentation is sufficiently rapid to avoid the necessity of using centrifugal force. The distilled water is, therefore, added by means of the jet, and the material in suspension allowed to subside for a suitable length of time, as in the beaker method. Two separations, the clay (0.005 to 0.0001 mm.) and fine silt (0.01 to 0.005 mm.), are thus made by the use of centrifugal force. The silt (0.05 to 0.01 mm.), is separated by simple subsidence. The material remaining in the tube constitutes

[1] Whitney, Bulletin 4, Division of Soils, U. S. Department of Agriculture, 1895, page 9.

e sands, which are dried and separated by means of sieves and bolt-
g cloth.

The clay water does not usually exceed 600 cc., while the fine silt
d silt together require about 500 cc. If these two last-named separa-
ns are allowed to stand for a day or more, they will, of course, settle
the bottom of the beakers, but the water in which they were sus-
nded will be found somewhat turbid, indicating the presence of clay.
matter how carefully the separations may be made, this turbidity
ll nearly always occur, indicating a slight disintegration of these
parations into finer material. This turbid water may be added to the
ter containing the "clay" in suspension if desired, although one will
justified in combining this suspended material with the sediment
m which it was obtained. This latter method is preferable in soils
taining large amounts of soluble material, such as the gypsum soils.
If desired, the silt and fine silt sediments can be confined to very
all volumes of water by again passing them through the centrifugal
paratus at a high velocity,
ich throws down all sedi-
nts, leaving the clear water
ich may be decanted. This
liment may then be washed
th a small quantity of water
o small platinum evaporat-
g dishes. As recommended
Hopkins, it is highly desir-
le to evaporate the whole of
e clay water, the volume be-
g so small as to permit this
ing readily done. Porcelain
shes are suitable for evap-
rating the liquid to a small volume, when it may be transferred to
atinum dishes for ignition.

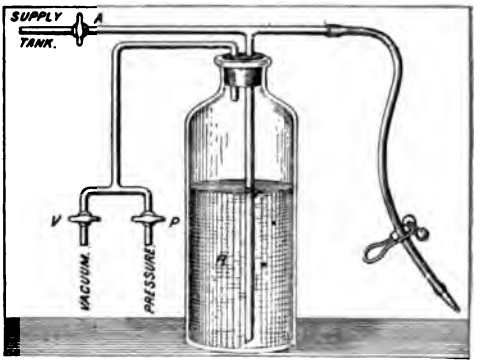


FIG. 11.—Apparatus for water pressure in mechanical analysis.

In figure 11 is shown the device employed for obtaining a jet of
stilled water under pressure. The air-tight reservoir R is filled by
ening the valve A in the pipe leading from the distilled water tank,
d by opening the vacuum cock V. After filling, V and A are closed
d air admitted from the pressure cock P, thus submitting the water
a pressure of about 8 pounds per square inch. This gives a jet suf-
iently strong to thoroughly stir up the sediment in the bottom of the
ntrifugal tubes, which through centrifugal action is packed so tightly
the tube as to permit an almost complete decantation of the water.

The following mechanical analyses in duplicate serve to illustrate
e accuracy which one may reasonably expect to attain in regular labo-
tory determinations, using the centrifugal method. These analyses
ere made by Mr. R. T. A. Burke, of this laboratory.

Mechanical analyses in duplicate by the centrifugal method.

Diameter.	Conventional name.	4333.		4335.	
		a.	b.	a.	b.
Millimeters.					
2. to 1.	Fine gravel			1.80	1.26
1. to 0.5	Coarse sand	0.11	0.09	.84	.88
0.5 to .25	Medium sand	.66	.62	1.26	1.16
.25 to .1	Fine sand	7.78	7.67	2.02	2.49
.1 to .05	Very fine sand	42.67	41.95	13.35	13.28
.05 to .01	Silt	27.04	28.65	34.52	35.49
.01 to .005	Fine silt	.85	.94	4.64	4.52
.005 to .0001	Clay	11.91	11.80	29.28	28.37
Loss at 110° C		1.03	1.01	2.14	2.18
Loss on ignition		6.87	6.80	8.30	8.16
Soluble salts		.95	1.01	1.68	1.69
Total		99.87	100.54	99.83	99.49

TREATMENT OF SEPARATIONS AFTER IGNITION.

In making mechanical analyses it is customary to determine the organic matter and combined water by igniting to redness a separate five-gram sample, which has previously been carefully dried at 100° to 110° C. It is consequently necessary to ignite also the several separations of the mechanical analysis before weighing the sample. If calcium or magnesium carbonates are present they are partially reduced through ignition to the oxides of these metals. These oxides must therefore be converted back into carbonates before making the final weighing.

The method commonly employed for this purpose, and the one recommended by the Association of Official Agricultural Chemists,[1] consists in treating the ignited separations with a saturated solution of ammonium carbonate after being cooled. The reaction may be expressed thus:

$$CaO+(NH_4)_2CO_3 \rightleftarrows CaCO_3+2NH_3+H_2O$$

The separations are then dried and afterwards heated to dull redness in order to drive off the ammonia, water, and excess of ammonium carbonates. They are then cooled in a desiccator and weighed. Such treatment is not necessary for normal sodium or potassium carbonates, as these salts are stable and non-volatile at a red heat.

This method answers very well if the separations contain only carbonates. If, however, chlorids, sulphates, or nitrates are present two sources of error occur.

In the first place, these salts are more or less volatile at the red heat required to burn off *all* the organic matter, so that an actual loss from volatilization will occur to some extent. Unfortunately, this difficulty is inherent in the method of determining organic matter by loss on combustion, which is the most satisfactory method available in connection with mechanical analyses.

[1] Methods of Analysis, 1898. Bul. No. 46, Div. of Chemistry, U. S. Dept. of Agr.

Secondly, if chlorids, nitrates, or sulphates are present in the ignited separations, the addition of ammonium carbonate to convert the oxides into salts in the formation of the ammonium salts of these acids. The reaction between the two salts is similar to that mentioned when speaking of gypsum in the presence of some other salt, and a condition of equilibrium is reached in exactly the same way. The class of reactions may be represented as follows:

$$(1)\ CaSO_4+(NH_4)_2CO_3 \lesssim CaCO_3+(NH_4)_2SO_4$$
$$(2)\ 2NaCl+(NH_4)_2CO_3 \lesssim Na_2CO_3+2NH_4Cl$$
$$(3)\ 2NaNO_3+(NH_4)_2CO_3 \lesssim Na_2CO_3+2NH_4NO_3.$$

The ammonium salts of the above-mentioned acids are all volatile and will, of course, be driven off when the separation is heated to remove the excess of ammonium carbonate. The error from this source has called attention to some time ago by Hilgard and Jaffa.[1] If chlorids, nitrates, or sulphates are present in considerable quantities, the above reactions will be indicated by the presence of the characteristic dense white fumes of the corresponding ammonium salts, which are freely given off at comparatively low temperatures. Ammonium carbonate shows no fumes on vaporization.

By successive treatments with ammonium carbonate it is possible to remove all of the negative or acid ions in this way, the positive or basic ions with which they were originally combined remaining as carbonates. The fact that a salt non-volatile at low temperatures is formed at the same time as the volatile ammonium salt reduces considerably the loss due to the above reaction, owing to the similarity in the reacting weights of the initial and residual salts as, for example, NaCl and $\frac{1}{2}$ Na_2CO_3. The change in reacting weights for the three cases considered is given below:

Salt.	Reacting weight.
$CaSO_4$	68
$CaCO_3$	50
NaCl	58.5
Na_2CO_3	53
$NaNO_3$	85
Na_2CO_3	53

This may, in part, account for the failure of soil analysts in general to consider this important source of error, particularly in connection with alkali soils.

As pointed out by Hilgard and Jaffa,[2] this loss may be avoided and the oxides converted into carbonates by treating directly with carbonic acid gas. A small amount of water is added to the ignited soil through which carbonic acid from a Kipp's apparatus is allowed to pass slowly for one or two hours. The separations are then evaporated to dryness and ignited at a *dull* red heat. The separate sample employed in determining the organic matter must also be subjected to the same treatment.

[1] Proceedings of the Society for the Promotion of Agricultural Science, 1888, p. 40.
[2] *Loc cit.*

DETERMINATION OF WATER-SOLUBLE MATERIAL.

A determination of the amount of water-soluble salts in a soil s heretofore seldom been made in connection with a mechanical analy This determination is of so much importance and interest, especi in connection with soils requiring irrigation, that it is now perform in this laboratory for all soils.

Two methods are available for this determination: First, the ev oration to dryness of an aliquot part of the clear solution and weigh the solute; second, the determination of the concentration of the so tion through its electrical conductivity, computing from this data a the volume of the solution the amount of salt.

The greatest difficulty in using the gravimetric method is to obt the solution clear and free from suspended or colloidal clay. This best effected by the use of repeated filtration through hardened filte This process is, however, very laborious, and with some soils it almost impossible to separate the clay, while with other soils the cl readily flocculates, either subsiding and leaving a clear supernata liquid, or forming aggregates which can readily be removed by fi filter. In most cases this flocculation appears to be due to a rath large amount of salts in solution. Evaporation to dryness will som times prevent clay from becoming suspended when water is aga added. Ignition will nearly always accomplish this, but at the expen of a portion of the salt content, as will be shown later.

The electrical method of determining the soluble salt content h the important advantage of not requiring any filtration of the solutio the presence of the suspended clay having no appreciable influen upon the conductivity. The determination is consequently very rapi consisting simply in measuring the specific resistance of the solutio and noting its temperature and volume. The resistance of the solutio is conveniently determined with the apparatus previously described b the writer.[1]

The transformation of the observed electrical resistance of the sol tion into terms of solution concentration may be performed by one the three following methods:

(1) The approximate composition of the salts in an area throughou which the composition (not the amount or concentration) may be fair assumed to be uniform is determined by chemical analysis. An aqueo solution of these salts of known concentration is then prepared, th salts being present in the solution in the proportions previously foun by the analysis. From this standard solution other solutions of reg larly diminishing concentration are prepared and the electrical resis ance of each determined in the electrolytic cell to be used in subse quent measurements. From these data a resistance-concentration curv

[1] Electrical Instruments for Determining the Moisture, Temperature, and Solubl Salt Content of Soils, Bulletin No. 15, Division of Soils, U. S. Department of Agri culture, 1899.

a be constructed, from which the concentration of any unknown soil m that area can at once be determined if its electrical resistance is own. The original solution must exceed in concentration any of the utions of unknown concentration, while all solutions must be reduced a common temperature. This reduction is very simple, a table for s purpose being given in Bulletin No. 7 of this division.

The weight of the soil used and the volume of the solution being own, the amount of the soluble salts in any sample can be expressed a percentage of the dry weight of the soil. As far as accuracy is ncerned, this method is practically as reliable as a direct determina- n by the gravimetric method. On account of the time required for necessary chemical analysis this method is not well adapted to a ermination of the salt content of a small number of samples unless hemical analysis of the water-soluble material has been made for er purposes.

(2) The second method of determining the soluble salt content con- ts in making a concentrated solution from a soil crust or a soil highly arged with salts. A portion of this solution is evaporated to dry- ss, in order to determine the concentration, while from the remaining rtion a series of solutions of decreasing concentration is formed, the istance of each solution being determined as before and the resist- ce-concentration curve prepared. This method requires much less eliminary work than the first, and is just as accurate, having a gravi- tric basis. A quantitative knowledge of the composition of the sol- le material in this case is not obtained.

(3) If the sample is an isolated one, or if the number of samples from y locality is so small that it is not desired to prepare a resistance- ncentration curve, a very fair approximation to the salt content can obtained by using a resistance-concentration curve for some single lt, such as sodium chlorid. For dilute solutions, all of the more rongly dissociating salts, such as chlorids, nitrates, and sulphates, are actically ionized to the same extent. Aside from the slight differ- ces in the migration velocities of the ions, which in this case may be glected, these strongly dissociating salts in dilute solution have actically identical concentration-resistance curves, if we use ionic ncentration in place of the conventional mass of the solute, or, in her words, if we express the concentration in gram-molecules instead in percentage of solute by weight in the solution. Therefore, it is acticable to use this common concentration-resistance curve (the con- ntration being expressed in gram-molecules) to determine the salt ntent of dilute soil solutions. To convert this determination into rams of solute per liter, it is simply necessary to multiply it by the acting weight of the salt in the terms of which it is desired to express e concentration. The per cent of salt as determined by this method ill consequently vary somewhat, depending upon the reacting weight f the salt chosen as a basis of computation. For example, if the

solute was computed as sodium chlorid the factor used would be
while for sodium sulphate (a bivalent salt) the factor would be 142
or 71.

Using a concentration-resistance curve computed on a gram-molec
basis, we can thus compute the salt content in terms of any salt desir
If it is preferred to express all results in terms of some single salt or
combination of salts, a resistance-concentration curve can be prepar
directly as in the first two methods, the concentration being expres
in terms of the mass of solute.

In the salt determinations made in this laboratory in connection wi
the mechanical analyses no effort has been made to maintain a consta
relation between the amount of soil and the volume of the solvent. T
volume of the water necessary in separating the clay (about 600 c
is so large in comparison with the amount of salt in a 10-gram samp
of soil that a considerable variation in the volume of the solvent wou
have but little influence upon the amount of salts in solution, excep
in the case of slightly soluble salts. Since these salts under soil con
ditions exert but little influence upon the plant, so far as their concen
tration is concerned, the procedure outlined appears justifiable.

The "clay" water is generally found to contain the principal portion
of the soluble matter, which is determined and subtracted from the
weight of the combined clay and salt separation to give the amount o
clay. The presence of any appreciable amount of salt in the "fin
silt" or "silt" waters is easily determined by the instrument; and i
can be neglected, combined with the clay water, or determined an
subtracted from the "fine silt" or "silt" determinations as the cas
demands.

The following table gives the salt content of three alkali soils deter
mined by three different methods. These soils were selected to show
wide variations in their soluble salt content. The determinations wer
made by Mr. W. G. Smith of this laboratory.

Salt content.

Catalogue No.	1.	2.	3.
	Per cent.	*Per cent.*	*Per cent.*
4115	1.60	1.08	0.8
4119	5.40	4.65	4.8
4131	3	2.70	2.6
Average	3.33	2.81	2.7

The first column of the table gives the catalogue number of the soils
investigated. Column 1 gives the per cent of salt found by the elec
trical method after two grams had been left to stand for six days in
contact with 600 cc. of water. The salt is expressed as the percentage
of the dry weight of the soil. Column 2 gives the per cent of salt found
after evaporating the solutions used in No. 1 to dryness, igniting, dilut
ing to 600 cc., and allowing them to stand for six days. Column 3 give

e salt content determined gravimetrically by evaporating to dryness e clear solution used for the determination given in column 2. No fficulty is experienced in obtaining a clear solution from any ignited il, the clay seldom showing any tendency to remain in suspension ter ignition.

The results of the table show that the determination of the salt con- nt after ignition is not advisable, a considerable portion of the soluble atter either being driven off during ignition or else converted into an soluble form. The results of columns 2 and 3 show a satisfactory greement between the electrical and gravimetric determinations, con- dering that the concentration-resistance curve used in converting the ectrical determinations was one prepared for a series of soils, of which e three samples selected formed but a small proportion. The salt terminations in the two duplicate analyses given on page 178 serve to lustrate further the accuracy of the electrical method.

SALTS AS INFLUENCING THE RATE OF EVAPORATI OF WATER FROM SOILS.

By LYMAN J. BRIGGS.

INTRODUCTION.

The physical properties of water which influence the rate of evap ration from a soil surface are surface tension, viscosity, and vap pressure. Since these factors are all modified to a greater or less degr by the addition of different quantities of salts, it is of interest to consid the influence of various salts in solution upon the evaporation of wate from soils.

The surface tension of an aqueous solution of a salt is higher tha that of the solvent. It appears from the work of Dorsey[1] upon *dilut* solutions and of Sentis[2] upon solutions greater than one-half norma that the surface tension is a linear function of the concentration. *Thi* may be represented by

$$T_s = T_w + Kc$$

in which T_s is the surface tension of a solution containing c gram equiv alents per liter, T_w the surface tension of water at that temperature, and K a constant varying with different salts. For sodium chlorid *this* constant K may be taken as 1.5 dynes, and for sodium carbonate as 2 dynes per square centimeter. Since the surface tension of pure water is about 73 dynes per square centimeter at 18° C., a difference of one gram equivalent in the concentrations of two portions of the soil solution would cause an increase in the surface tension of 2 per cent for sodium chlorid and 2.6 per cent for sodium carbonate.

The writer[3] has previously pointed out that the capillary movement of water in soils is due to the pressure of the peculiar capillary surface formed by the water in the capillary space about the point of contact

[1] Physical Review, 5, p. 228, 1897.

[2] Jour. de Phys. (3), 6, p. 183, 1897.

[3] The Mechanics of Soil Moisture, Bulletin No. 10, Division of Soils, U. S. Department of Agriculture, 1897.

wo soil grains. The pressure of such a surface may be repre-
d by

$$P = T\left(\frac{1}{r_1} + \frac{1}{r_2}\right)$$

hich P is the pressure, T the surface tension, and r_1 and r_2 the two
ipal radii of curvature. Since T is involved only as a linear func-
a small change in T can only produce a proportional change in P.
equently the small changes in T, which amount to only 2 per cent
e extreme variations considered, can practically be neglected as
pared with the much greater variations in the value of r. In other
ds, the salts in solution play a minor part as compared with the
ature of the water surfaces in determining the capillary movement
ater in soils.

nce the viscosity of a solution increases with the concentration,
presence of large amounts of soluble salts would retard to some
nt the movement of water in the soil, and so lessen the rate of
oration by limiting the movement toward the surface. Arrhenius
found that the relation between viscosity and concentration for a
e number of solutions can be expressed by the equation:

$$\mu_n = \mu_1^n$$

which μ_n is the specific viscosity of a normal solution referred to the
vent at the same temperature and n the number of gram-molecules
the solution under consideration. For example, a normal solution
sodium chlorid has a specific viscosity of 1.097, or about 10 per cent
eater than water. The specific viscosity of a two-normal solution
ould be 1.20 and a half-normal 1.04. Since a saturated solution of
dium chlorid at ordinary temperatures contains approximately five
ram-molecules per liter, the specific viscosity under such conditions
ould be 1.59. In alkali soils, therefore, where the salts are present
n excess, the increased viscosity of the solution would decrease the rate
of movement of water to a considerable extent. It should be noted in
this connection that the effect of increased concentration is to increase
the surface tension, and thus increase the rate of movement. The two
factors, consequently, oppose each other, and the resultant change in
the rate of movement of water due to change in concentration is much
less than if either factor existed alone.

Finally, the vapor pressure of a salt solution decreases with increase
of concentration. The vapor pressure of a normal sodium sulphate solu-
tion at 100° C. is 25 millimeters less than the pressure of water vapor
at that temperature. The variation in vapor pressure from that of the
solvent at other temperatures has not been determined for this salt;
but approximate values can be ascertained by comparison with the
approximate normal solution of potassium hydrate, for which the vapor

tension at various temperatures has been determined.[1] In the following table the first column gives the temperature, the second and third columns give the vapor pressure of the solution and of the water at the temperature considered, while the fourth column gives the temperature to which it would be necessary to cool pure water in order to make its vapor pressure equal to that of the potassium hydrate solution:

Temperature °C.	Vapor pressure.		Temperature of water for equal vap. pr.
	16.6 per cent KOH.	Water.	
			°
10	8.01	9.14	8.1
16	11.85	13.51	13.9
20	15.25	17.36	17.9
25	20.67	23.52	22.8
30	27.74	31.51	27.8
34	34.84	39.52	31.8

It will be seen from the table that the evaporation from a normal salt solution at 30° C. into vapor free space is the same as with pure water at 27.8°. A certain conservation of the moisture would consequently follow. However, even with a normal solution this is not very marked and could only have an important effect in case the soil moisture is saturated with the salt. A saturated solution of sodium carbonate would correspond in rate of evaporation to a lowering of temperature of about 10° C., assuming the evaporation to be taking place in a vacuum.

There is another factor which probably exerts more influence upon the rate of the evaporation of water than any of the factors mentioned, namely, the physical condition of the surface of the soil. Hilgard has pointed out that some of the so-called alkali salts, especially sodium carbonate, exert a marked influence upon the physical character of the soil. Buffum[2] calls attention to this fact and also states that alkali soils may appear damp when adjoining lands seem dry. To explain this phenomenon he conducted experiments on soils which had been moistened with solutions of salts. The salts used were sodium carbonate, sodium chlorid, sodium sulphate, and magnesium sulphate in solutions varying in concentration from 0.1 per cent to 9 per cent. The general results of the experiments show that the amount of water lost from the pots containing 9 per cent solutions (which is equivalent to 2.2 per cent alkali, in a soil containing 25 per cent of the solution) was approximately one-half as much as that from soils containing the same percentage of pure water. The effect of the presence of soluble salts in the soil on the evaporation, in Buffum's experiments, was so much

[1] Landolt and Bornstein, "Phys. Chem. Tab.," S. 68.

[2] Bulletin No. 39, Wyoming Experiment Station, p. 55, 1898.

greater than would be expected from the theoretical considerations given in the first part of this paper that the writer was led to believe that this difference was due to a change in the surface conditions of the soil from the accumulation of salts rather than from the presence of the salts in solution. In other words, either the formation of a mulch or the crusting of the soil at the surface had taken place, preventing evaporation to some extent. To test the validity of this opinion the following experiments were planned:

(1) The evaporation of water from soils spread out in thin layers in large trays, one sample being moistened with distilled water and the other with a salt solution. The soils in both trays to be stirred from time to time in order to prevent any possible crusting of the soil. This would indicate whether the abnormal lessening of the evaporation observed by Buffum was due to a surface condition.

(2) The relative rate of evaporation in open dishes of pure water and solutions of the concentration used in experiment (1), as a check upon the conditions observed during that experiment.

(3) Evaporation from the surface of soils packed in tall, narrow cylinders and moistened with pure water and salt solutions, as a repetition of Buffum's experiments. This arrangement would serve to accentuate the effect of the crusting of the surface.

The soil used in all the experiments was from James Island, South Carolina, being the soil upon which the Sea Island cotton is grown. The texture is shown in the accompanying mechanical analysis, made by Mr. W. G. Smith, of this laboratory:

Diameter.	Conventional name.	86. James Island, S. C.
Millimeters.		*Per cent.*
2 to 0.1	Fine gravel	0.00
1 to .5	Coarse sand	.37
.5 to .25	Medium sand	6.01
.25 to .1	Fine sand	79.15
.1 to .05	Very fine sand	2.50
.05 to .01	Silt	.55
.01 to .005	Fine silt	4.23
.005 to .0001	Clay	4.60
	Loss at 110° C.	.83
	Loss on ignition	1.85

SODIUM CHLORID.

Experiment 1.—To test the influence of the salt content of the soil upon the rate of evaporation of water from the soil, two samples of soil containing 200 grams each were moistened, respectively, with 40 grams of pure water and normal sodium chlorid solution. These soils were spread out in two shallow photographic trays of the same size, measuring approximately 8 by 10 inches. The soil containing the salt solution was frequently stirred, in order to prevent the possible formation of a crust at the surface. The soil in the other tray was also stirred at

the same time, in order to treat the two soils as nearly alike as possible. The results of the experiment are given in the following table, and shown graphically by the accompanying curve (fig. 12):

Evaporation from soil exposed in trays, moistened with water and normal NaCl solution.

Time (minutes).	Water evaporated (grams).	
	Water.	NaCl solution.
0	0	0
50	11.5	10
90	20.6	18.8
130	29.6	26
160	32.3	28.5
235	36.2	32.1
295	39.5	35.5

As it was not possible to keep the conditions of evaporation constant, the time intervals serve only as an indication of the rate at which the

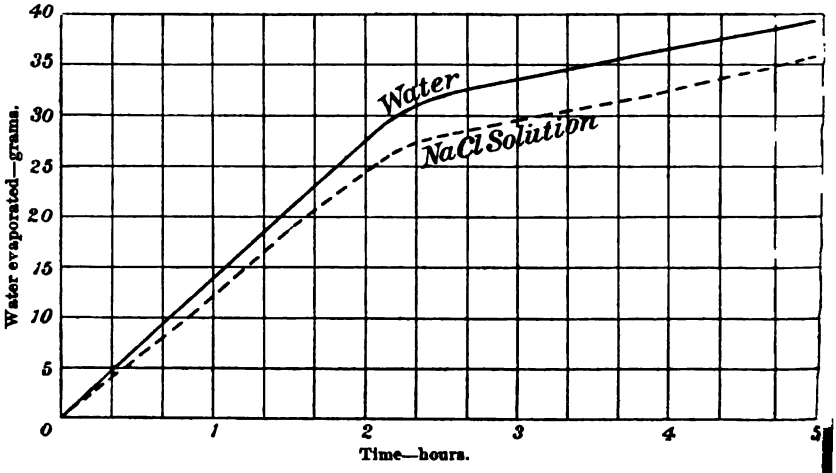


FIG. 12.—Diagram showing evaporation from soil in trays, moistened with water and NaCl solution.

evaporation was taking place. The drying was carried on in a room at a temperature of about 25° C., the air above the trays being kept constantly in motion by means of a fan, and the trays being frequently interchanged to prevent an error due to their position.

It is seen in the table that the rate of evaporation was about 10 per cent greater from the soil moistened with distilled water. It should be remembered that the concentration of the solution in the soil containing the salt constantly increases as the evaporation goes on, and on this account the evaporation should gradually decrease. The actual concentration of the solution in the soil is a matter of more or less conjecture, since the measurements of the electrical conductivity of a soil moistened with salt solution indicate that an appreciable amount of the salt originally added in the form of solution does not remain in solution in the presence of the soil grains. The conductivity of a solution is at least very materially lowered by the addition of the soil, indicating that

sical absorption has taken place and that part of the ions of the are no longer free to move.

Experiment 2.—To determine whether the difference in the evaporation erved in Experiment 1 was more than could be accounted for by the erence in the physical properties of the salt solution and pure water, experiment was conducted to determine the difference in the rate of evaporation of the two solutions. One hundred grams of distilled ter and of a normal solution of sodium chlorid were placed in two ri dishes 3⅜ inches in diameter and five-eighths of an inch deep. se dishes were so placed as to be subjected to the same conditions, ough no attempt was made to keep these conditions constant. The e of evaporation is shown in the accompanying table:

Table of evaporation from Petri dishes

Time.	Distilled water, total loss.	NaCl solution, total loss.
Hours.	*Grams.*	*Grams.*
1½	.9	.9
4½	2	2
23½	12.8	11.8
27½	15.3	14.3
30	18.3	17.1
49⅝	35.3	32.3
53⅝	41	37.7
95⅛	63.5	58.1
121⅞	74.3	66.8
143⅓	82.6	73.3

From this table it will be seen that the relative rate of evaporation the distilled water and the salt solution was not sensibly different

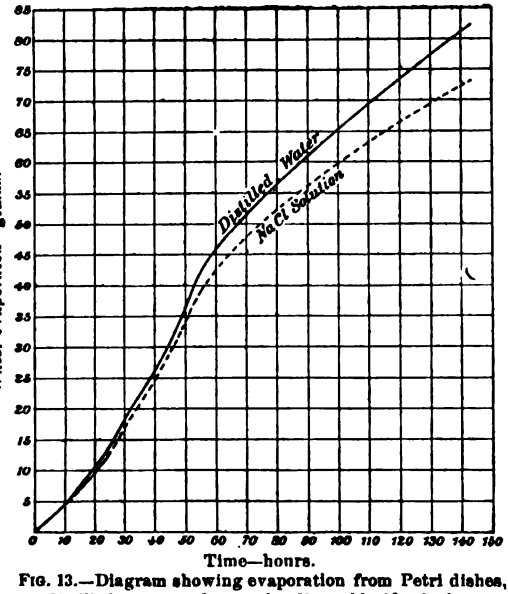


FIG. 13.—Diagram showing evaporation from Petri dishes, distilled water, and normal sodium chlorid solution.

ien freely exposed in aporating dishes than ien mixed with the soil. om this we are justified concluding that the aporation of water from e salt solution is not cessarily modified to y appreciable extent by ving this solution in conct with the soil grains. other words, the evapation of the water from soil would be modified ly by the presence of luble salts so far as these luble salts would influce the evaporation of a lution of similar concenation when freely exosed to the air. This ould not amount, as we have seen, even in the case of normal solutions, to more than 10 per cent. This is far from sufficient to explain he great difference noted by Buffum.

Experiment 3.—It remained to test the opinion of the writer—th the results obtained by Buffum were due to the formation of the cr at the surface of the soil. Accordingly two cylinders 2 inches diameter and 11 inches high, holding 800 grams of soil, were fill with samples of soil moistened with 20 per cent of distilled water a with normal sodium chlorid, respectively.

To supplement these, a third cylinder of the same dimensions w filled with a soil containing 20 per cent of distilled water to with one-eighth of an inch from the top of the cylinder. The remainin one-eighth inch was filled with pulverized sodium chlorid. These cyli ders were kept under similar conditions and the loss of moistu determined by weighing them from time to time. The results are give in the accompanying table:

Table of evaporation from cylinders of soil containing 20 per cent distilled water, 20 p cent normal NaCl, and NaCl on surface.

Time.	Distilled water, total loss.	Normal NaCl solution, total loss.	NaCl on surface, total loss.
Hours.	*Grams.*	*Grams.*	*Grams.*
17	6	0.5	.....
24	9	3.5	.....
65	19	9	6
120	27	13	10.5
148	32	15.5	13.5
170	38.5	18	15
197	46	21	17.5
222	53	24.5	21.5
245	60	27.5	24
288	70	30.7	28.3
337	81.5	35.5	33.5

The rate of evaporation of water in the three tubes is more clearly shown in the accompanying diagram. The irregularity of the curve is due to the fact that uniform conditions of evaporation could no be maintained. It will be noticed, however, that these irregularitie appear in all curves, showing that the tubes were similarly influenced

From these curves it is evident that the rate of evaporation from th soil containing distilled water was about twice that from the soil moistened with the normal salt solution, confirming in a general way Buffum's experiment. Consequently, we are justified in concluding that for this salt the marked diminution in evaporation is due mainly to surface conditions.

A peculiar condition was noticed in connection with the soil which was moistened with the salt solution. During the evaporation of the water the salt crystallized just beneath the surface of the soil, leaving it in a very loose and porous condition; in fact, after the evaporation had proceeded some time, the surface of the soil in this tube was raised one-half inch or more above the mouth of the tube, due to the formation of minute crystals of the salt interspersed among the soil grains. This tends to confirm the idea that the decreased evaporation in a

kali soil is due to the formation of a natural mulch, through the ystallization of the soluble salts at the surface, which so loosens the rface as to decrease the evaporation materially.

In the tube in which the soil was covered with a layer of pulverized lt no loosening of the surface was noticed, but the salt seemed to rm a solid incrustation over the surface of the soil, reducing the aporation. The equality in the slope of the two salt curves is impor-nt in showing that the influence of the concentration on viscosity d surface tension need not be considered in this case.

SODIUM SULPHATE AND SODIUM CARBONATE.

In order to determine whether the conclusions drawn from the periments with sodi- chlorid applied to all the more abundant alkali" salts, experi-ents similar to those st described were made ith sodium sulphate and dium carbonate by Mr. . H. Lapham, of this boratory.

Experiment 1.—This as conducted practically e same as described in e corresponding experi-ent with sodium chlorid, cept that the determi-ations for each salt were ade in duplicate. Four 0-gram samples were posed in trays, two be-g moistened with 40 rams of water, and the hers with 40 grams of normal solution of the lt under investigation.

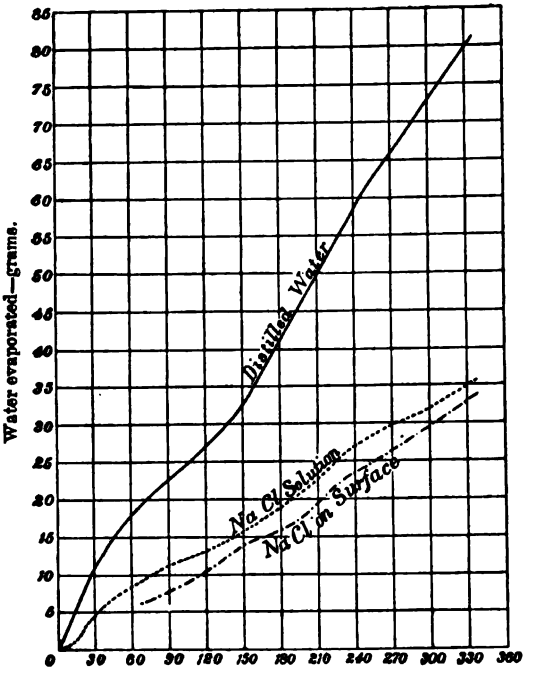


FIG. 14.—Diagram showing evaporation from cylinders moistened with distilled water and sodium chlorid solution.

The results given in the following table are mean of the duplicate determinations. These are also expressed raphically in figures 15 and 16. It will be noticed that at first he salt has little influence upon the rate of evaporation of the water om the surface of the soil. As the concentration increases and the oil becomes drier the influence of the salt is more marked. In this xperiment the greatest diminution in the rate of evaporation produced y the sodium sulphate does not exceed 10 per cent. The experiment ith sodium carbonate (figure 16) gave practically the same results.

Table of evaporation of distilled water and normal Na_2SO_4 from soil in trays.

Time.	Distilled water, total loss.	Normal Na_2SO_4, total loss.
Hours.	*Grams.*	*Grams.*
0½	1	1.30
1	2.40	2.55
1½	3.60	3.65
2	5.55	5.60
2½	7.50	7.30
3	9.70	9.30
3½	11.55	10.90
4	13.30	12.45
4½	14.85	13.85
5	16.70	15.55
5½	18.40	16.90
6	20.30	18.50
6½	22.15	19.90
7	23.55	21.15
7½	25.25	22.75
8	26.90	24.25
8½	28.20	25.45
9	29.45	26.60
9½	30.65	27.70
10	31.70	28.55

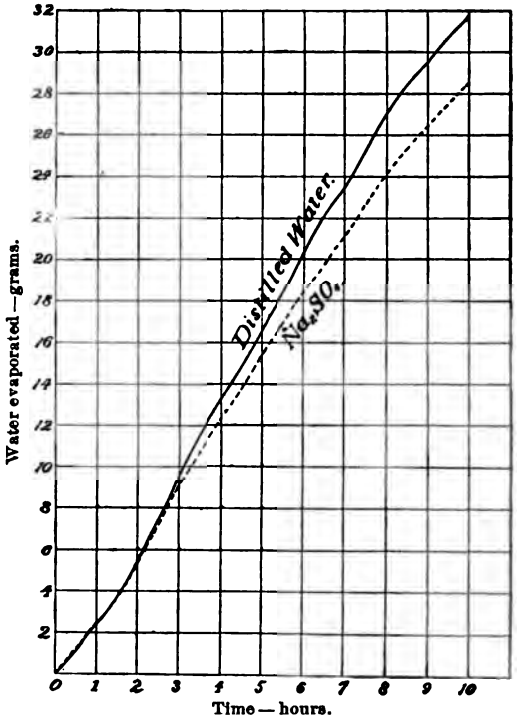


FIG. 15.—Diagram showing evaporation from soil in trays moistened with distilled water and sodium sulphate solution.

Table of evaporation of distilled water and normal Na_2CO_3 solution from soil in trays.

Time.	Distilled water, total loss.	Normal Na_2CO_3, total loss.
Hours.	*Grams.*	*Grams.*
½	2.25	2.15
1	3.95	3.70
1½	5.80	5.35
2	8.30	7.80
2½	9.85	9.30
3	11.30	10.50
3½	13.50	12.45
4	15.30	13.90
4½	17.35	15.75
5	19.40	17.66
5½	21.30	19.20
6	22.60	20.25
6½	24.05	21.35
7	25.05	22.15
7½	26.10	22.95
8	27.05	23.90
8½	28.25	24.80
9	28.90	25.55
9½	29.55	26.05
10	30.30	26.65

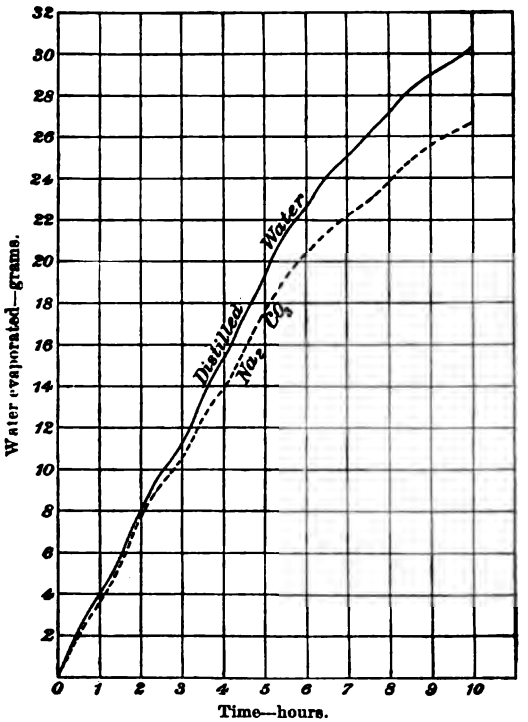


FIG. 16.—Diagram showing evaporation from soil in trays moistened with distilled water and normal sodium carbonate solution.

Experiment 2 A.—These experiments were conducted for the purpose of determining the relative rate of evaporation from the surfaces of pure water and salt solutions under ordinary atmospheric conditions of temperature, pressure, and humidity. The water and the salt solutions were exposed in Petri dishes of the same diameter and depth.

The air above the dishes was kept gently moving by means of an electric fan, and all precautions to obtain uniform conditions were observed. The results of the experiments are given in the following table and shown graphically in fig. 17:

Table of evaporation of distilled water and normal Na_2SO_4 and Na_2CO_3 solutions from Petri dishes.

Time.	Distilled water, total loss.	Normal Na_2SO_4, total loss.	Normal Na_2CO_3, total loss.
Hours.	*Grams.*	*Grams.*	*Grams.*
1	1.10	1.05	1.10
2	2.20	2.10	2.20
3	3.45	3.20	3.30
4	4.45	4.30	4.40
5	5.15	5.00	5.10
6	6.00	5.80	5.80
7	6.75	6.50	6.60
8	7.50	7.30	7.30
9	8.40	8.20	8.20
10	9.40	9.10	9.20
11	10.35	10.00	10.10
12	11.25	10.80	10.90
13	12.30	11.80	11.85
14	13.35	12.80	12.80
15	14.15	13.60	13.70
16	15.10	14.50	14.60
17	15.90	15.20	15.30
18	16.75	16.00	16.20
19	17.60	16.90	17.00
20	18.15	17.40	17.50
21	18.80	18.00	18.20
22	19.50	18.80	18.90
23	20.25	19.40	19.50
24	21.05	20.20	20.30
25	21.60	20.70	20.90
26	22.40	21.40	21.60
27	22.95	22.00	22.20
28	23.50	22.50	22.70
29	24.10	23.00	23.20
30	24.65	23.50	23.70
31	25.25	24.00	24.30
32	25.95	24.60	24.90
33	26.50	25.10	25.50
34	27.10	25.60	25.90

The evaporation curves for the solutions are displaced to the right to avoid confusion. The concentration beginning with normal solution increases with evaporation until a saturated solution of sodium sulphate is obtained. The three solutions, however, show very little difference. The sodium carbonate solution evaporated a little more rapidly than the other, probably due to the fact that it does not dissociate so strongly as sodium sulphate, and hence has a higher vapor pressure. Neither of these solutions show anything like the diminution in the rate of evaporation which we should expect from theoretical considerations of the lowering of the vapor pressure due to the concentration. Consequently, we are led to conclude that the rate of the diffusion of the water vapor under ordinary conditions is the controlling factor, and that the concentration of the solution would play the more important part only when the surface of the solution is continually being supplied with vapor-free air.

Experiment 2 B.—In order to substantiate more completely the conclusion that the evaporation from reservoir or soil is not diminished by

he presence of salt in solution to the extent which consideration of the wering of the vapor pressure would lead us to assume, a determination was made of the relative rate of evaporation of water and of saturated solutions of the three salts previously used. The solutions were xposed in Petri dishes as efore, while the surfaces f the liquids were contantly swept by a strong last of air from an electric buzz fan. The blast of ir was sufficiently strong o produce pronounced ipples on the surfaces of he liquids, particularly hat of the distilled water, he increased viscosity of he solutions somewhat iminishing this effect. herefore, the conditions f this experiment—the apid movement of air ver saturated solutions—re such as to give the aximum influence of the alts investigated on the diminution of evaporation under the given conditions of temperature and pressure. The results are shown in the following table and curve, fig. 18:

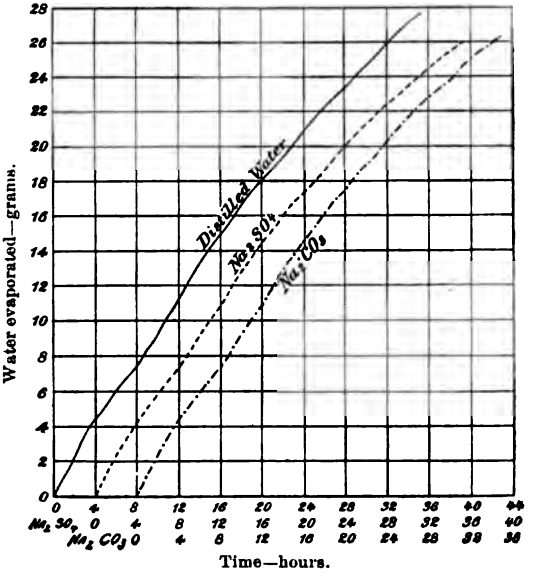


FIG. 17.—Diagram showing evaporation from Petri dishes, normal solutions.

Table of evaporation of distilled water and saturated solutions of NaCl, Na_2SO_4 and Na_2CO_3 from Petri dishes.

Time.	Dist. water, total loss.	NaCl, total loss.	Na_2SO_4, total loss.	Na_2CO_3, total loss.
Hours.	*Grams.*	*Grams.*	*Grams.*	*Grams.*
½	1	0.8	0.9	1
1	2.3	1.8	2.1	2.3
1½	4.2	3.5	4.0	3.9
2	5.6	4.7	5.5	5.3
2½	7.8	6.4	7.5	7.3
3	9.7	8	9.4	9
3½	11.1	9.3	10.7	10.2
4	12.9	11	12.6	11.8
4½	14.8	12.6	14.3	13.2
5	16.5	14.2	15.9	14.4
5½	17.8	15.2	17.3	15.5
6	19.1	16.4	18.6	Crystallized
6½	20.5	17.6	19.9	.....
7	.....	Crystallized.		.....

These results show a maximum diminution in the rate of evaporation of about 14 per cent. The average temperature of the laboratory was 19° C., while the average relative humidity was 45 per cent. An average of 15 grams of water was evaporated from each dish during six hours. Since the diameter of the dish was about 8.4 cm., this would correspond to an evaporation of 1.1 cm. per square centimeter of surface or 0.44 inch per square inch during twenty-four hours. The humidity and rate of evaporation are consequently such as to make the results of this experiment applicable to arid conditions.

Experiment 3.—This experiment was conducted similar to that for sodium chlorid. Three cylinders were filled with soil moistened with

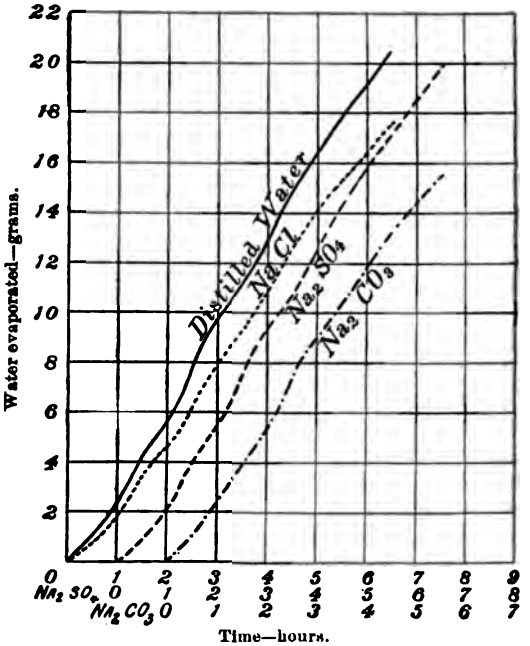


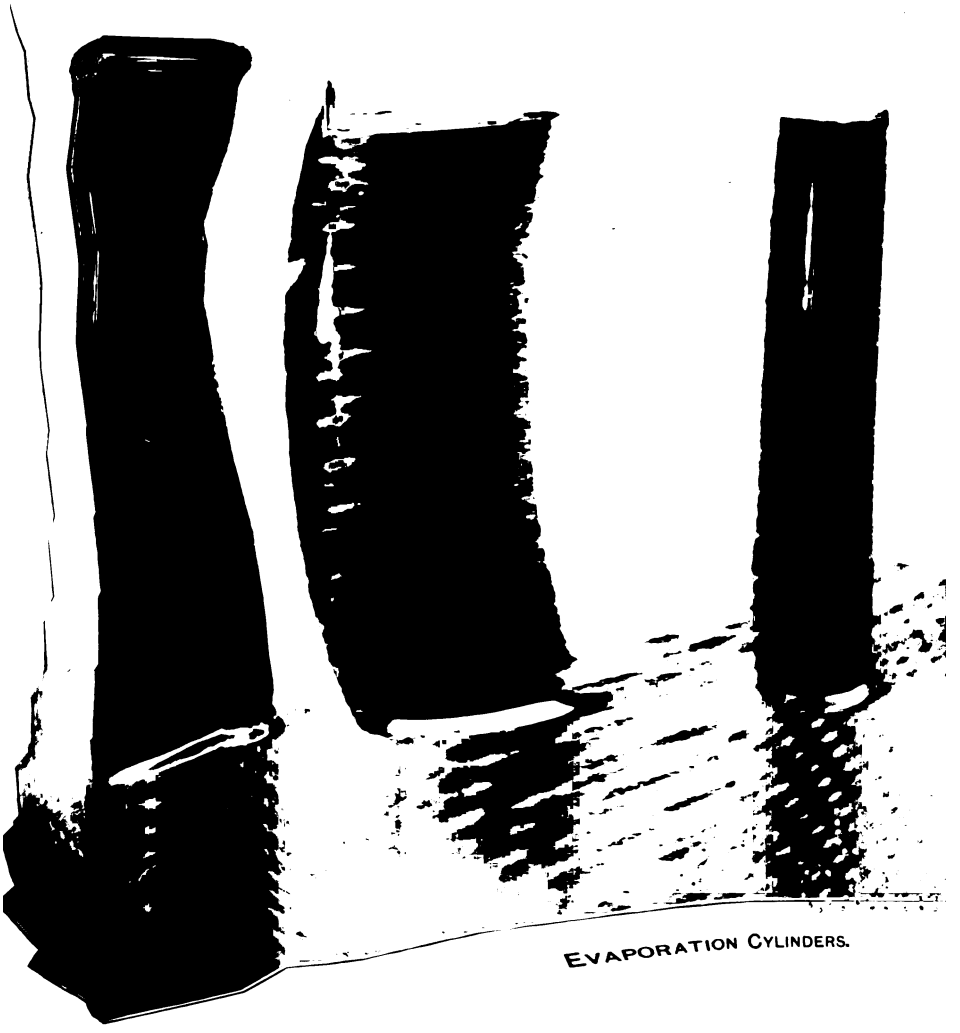
FIG. 18.—Diagram showing evaporation from Petri dishes, saturated solutions.

20 per cent by weight of distilled water and normal solutions of sodium sulhpate and sodium carbonate, respectively. In a fourth cylinder the soil was moistened with distilled water and mulched with a layer of sodium sulphate one-eighth inch thick. The results are shown in the accompanying table and curves, fig. 19:

Table showing evaporation from soil cylinders—Distilled water, normal $Na_2 CO_3$ and $Na_2 SO_4$ solutions, and $Na_2 SO_4$ mulch.

Time in days.	Distilled water.	Normal $Na_2 CO_3$.	Normal $Na_2 SO_4$.	Distilled water with $Na_2 SO_4$ as mulch.
	Total loss in grams.	*Total loss in grams.*	*Total loss in grams.*	*Total loss in grams.*
½	2.5	1.9	1.6	1.2
1	8.4	5.8	5.5	4.2
1½	11.2	7.2	7.1	5.6
2	17.6	11.0	11.4	9.4
2½	19.8	12.1	12.7	10.6
3	26.1	15.3	16.6	14.4
3½	28.2	16.4	17.9	15.7
4	34.4	19.2	21.8	19.4
4½	36.2	19.9	22.8	20.6
5	43.4	23.0	26.9	24.7
5½	45.3	23.8	28.0	26.0
6	50.9	26.4	31.8	30.0
6½	52.6	27.0	32.9	31.2
7	57.6	29.3	36.3	34.7
7½	58.9	29.8	37.1	35.6
8	62.7	31.5	39.5	38.2
8½	64.2	32.1	40.5	39.2
9	69.3	34.1	43.5	42.7
9½	70.7	34.5	44.2	43.7
10	75.2	36.3	47.1	46.8

Dept. Agr.



EVAPORATION CYLINDERS.

DO NOT
REMOVE

These experiments also corroborate those of Buffum, the evaporation om the cylinders containing salt being only from 50 per cent to 60 per nt of that from the cylinder moistened with distilled water. This minution in evaporation is, as we have seen, much greater than can e explained through the physical properties of solutions of these lts. Consequently this must be due to the formation of a mulch on e surface of the soil, resulting from the crystallization of the salt on vaporation. This is well exemplified in Plate XXIX, which repre-nts the condition of the tubes at the close of the experiment. The ose white efflorescence on the surace of the sodium sulphate soil is very arked. The accumula-on of salt in the sodium rbonate tube is much s marked, on account of e remarkable degree to hich this salt is absorbed by the soil and kept from ccumulating at the sur-ce. The crystallizing out f the soil at the surface oes take place to some xtent, but the white crys-ls are masked by the ac-ompanying organic mat-er which this salt brings into solution. The result-ant dark color of the sur-face, which so characterizes the presence of this salt in alkali soils, was very marked in the sodium car-bonate tube during the first part of the experiment. This is shown to some ex-tent in Plate XXIX. The tube containing the sodium sulphate as a mulch does not differ materially in its rate of evaporation from the tubes containing the solutions, showing that the conditions within the soil are secondary to surface conditions in alkali soils.

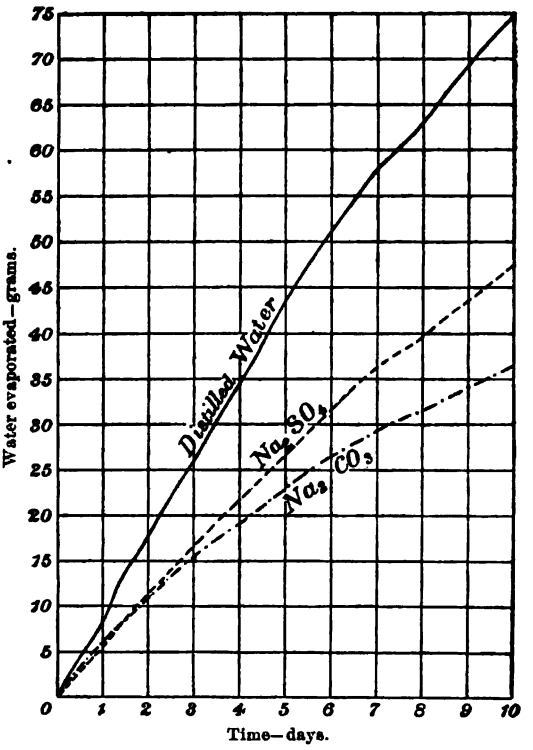


FIG. 19.—Diagram showing evaporation from cylinders of soil moistened with distilled water and with normal sodium carbonate and sodium sulphate solutions.

Sodium carbonate does not form at the surface the loose, fluffy mixture of soil grains and salt crystals so characteristic of sodium sulphate and sodium chlorid, but tends rather to the formation of a crust which is more or less broken and tilted by the subsequent crystallization beneath. This action, of course, depends upon the texture of the soil, and in field conditions this would be influenced by the presence of other salts.

CONCLUSIONS.

From the results given in the paper the following conclusions may be drawn:

(1) Salts influence the evaporation of water from the surface of a soil by changing the surface tension, the viscosity and the vapor pressure of the system, and the physical character of the soil, particularly at the surface.

(2) The surface tension and viscosity influence the rate of evaporation only through the modification of the rate of capillary movement. Both surface tension and viscosity increase with increase in concentration. An increase in surface tension increases the rate of capillary movement, while increase in viscosity diminishes it. These two factors, consequently, oppose one another.

(3) The rate of capillary movement within a soil is of secondary importance to the physical character of the surface, as modified by the presence of crystallized salts.

(4) The relative rate of evaporation from a soil moistened with *pure* water and salt solution, respectively, is the same as for the water and solution without the soil, providing no surface mulch is formed.

(5) The rate of evaporation gradually decreases with increase in concentration.

(6) The diminution of evaporation with increasing concentration is much less than the corresponding diminution in vapor pressure. *This* is due to the fact that the atmosphere is never vapor-free and that the diffusion of water vapor is retarded by the surrounding air.

(7) The diminution of evaporation of soils containing solutions of "alkali" salts is much greater than can be accounted for through the influence of the lower vapor pressure, and is due to the formation of a mulch at the surface of the soil through the crystallization of the salts.

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S. 31.
A.P.P.73.

To

U. S. DEPARTMENT OF AGRICULTURE

Report No. 65.

PHYSIOLOGICAL STUDIES

OF

CONNECTICUT LEAF TOBAC

U.S. DEPARTMENT OF AGRICULTURE

BY

OSCAR LOEW,

OF THE DIVISION OF VEGETABLE PHYSIOLOGY AND PATHOLOGY

DETAILED TO THE DIVISION OF SOILS.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1900.

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RECENT PUBLICATIONS OF THE DEPARTMENT ON TOBACCO.

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
DIVISION OF SOILS,
Washington, D. C., March 24, 1900.

SIR: I have the honor to transmit herewith a manuscript concerning some physiological studies of Connecticut leaf tobacco by Dr. Oscar Loew, of the Division of Vegetable Physiology and Pathology. These investigations are in continuation of the cooperative work between this Division and the Division of Vegetable Physiology and Pathology in carrying out in the broadest sense the tobacco investigations authorized by Congress and in the critical and exhaustive study of the possibilities of the soils of the Connecticut Valley.

Respectfully,

MILTON WHITNEY,
Chief of Division.

Hon. JAMES WILSON,
Secretary of Agriculture.

LETTER OF SUBMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
DIVISION OF VEGETABLE PHYSIOLOGY AND PATHOLOGY,
Washington, D. C., March 20, 1900.

SIR: In accordance with a plan of cooperative work between this Division and the Division of Soils, I respectfully submit herewith the manuscript of a report on some physiological investigations of Connecticut leaf tobacco, by Dr. Oscar Loew. The work deals with a number of questions relating to the physiology of the leaf and the changes which take place during the processes of curing and sweating.

Respectfully,

B. T. GALLOWAY,
Chief of Division.

Prof. MILTON WHITNEY,
Chief, Division of Soils,
In Charge of Tobacco Investigations.

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PHYSIOLOGICAL STUDIES OF CONNECTICUT LEAF TOBACCO.

GENERAL PHYSIOLOGY OF THE TOBACCO PLANT.

THE FACTORS OF DEVELOPMENT.

The interest connected with the tobacco plant is not only of an agricultural and commercial nature[1] but is also to a considerable degree of a physiological and chemical character. First of all the minuteness of the seed strikes us as peculiar when compared with the large plant developed in but ninety days rivaling in extent of leaf surface most other cultivated plants of equal age. This rapid development requires a steady and full nutrition, if the leaves are to become of the desired size and quality. In order to accomplish this result the roots must be able to grow and extend with corresponding rapidity, requiring for this purpose not only a loose humus or a fine sandy soil to the depth of several feet, but also the presence of all necessary mineral nutrients in most easily assimilable form. The soil must, on the one hand, admit air freely to the finest rootlets to satisfy the wants of respiration and, on the other hand, it must be of such quality as not to part with its moisture too easily in a period of dry weather. The nature of the subsoil is also of great importance, since when it is impermeable the stagnant water is just as detrimental to the roots as too great loss of water on account of excessive permeability of the soil.[2]

The abnormal physiological condition created by the mutilating (topping and suckering) of the plant in order to obtain suitable leaves for the requirement of the tobacco manufacturer is also of interest. Further points of consideration are the production of the enzyms necessary for the processes of curing and sweating and, finally, the production

[1] The annual total tobacco production of the globe is estimated by Darmstädter to be nearly 1,000,000,000 kilograms.

[2] For full information on tobacco soils see Bulletin No. 11, Division of Soils, Tobacco Soils of the United States, 1898, by Milton Whitney. A tropical temperature might favor the development of the root in humus soil to such an extent that relatively less of mineral nutrient for the unit of soil will suffice for a normal plant development. The fact that some tobacco soils of Sumatra contain less of nutrients than tobacco soils in northern countries and still produce excellent crops is thus explained by A. Mayer.

of nicotine. All these points are of particular interest. Unless all the conditions necessary for the normal development of the plant are united various dangers menace the crop; and there may even be the development of a singular disease which annually causes immense damage, namely, the mosaic disease.

Among the various tobacco soils of Connecticut there are some that are better suited for broad leaf than for Havana seed as, for example, the soil at East Hartford, Conn., where the culture of the latter had to be given up, the fine cinnamon-brown color not having been attained on this kind of soil.

The weather also constitutes one of the most important factors as to the quality of the tobacco. Too moist as well as too dry years are injurious; the latter, however, more so than the former, since the leaves remain smaller and grow thick and become relatively too heavy; and, furthermore, show insufficient elasticity and frequently burn poorly. In too moist years the leaves remain weak, are attacked easily by fungi and, moreover, the aroma of the tobacco is injured. In rainy weather, especially when the temperature is rather low, the amount of acid in the leaves is also increased and this may exert a detrimental effect on the oxidizing enzyms in the curing process when the tobacco is harvested in such a condition. The oxidizing enzyms are the promoters of all desirable changes in the curing and the sweating process. Variable weather is the best. Van Bemmelen[1] says that the weather in Sumatra is generally more favorable than in Java where frequently extremes are observed. In Deli, Sumatra, occasional rains occur even during the dry monsoon. After twenty days of dry weather a rain is much desired there for tobacco. Forty days of dry weather are considered very injurious. The short showers falling through the period of tobacco growing are considered so important that a continuous record is kept on many tobacco plantations. It is principally the great rapidity of development that causes the fineness of the ribs and veins and the elasticity, making the tobacco leaves from Sumatra unsurpassed as wrappers.[2]

On warm bright days not only is much more carbon assimilated—that is, more starch, the mother substance of all the other organic constituents of the plants, is formed. but also the respiration is increased by the high temperature, although not to such an extent as to consume all the starch increased by the bright light. All processes of metabolism are thus promoted by warm and bright days, undesirable by-products may be destroyed and favorable products formed. How differences of temperature influence the intensity of the respiration process may be seen from the following data. While Behrens observed, for 100 grams fresh tobacco leaf at 21° C. (69.8° F.), a production of 0.254 grams of carbonic acid in ten hours, Déherain and Moissan ob-

[1] Landw. Vers. Stat., vol. 37, p. 385.

[2] Report No. 62, U. S. Department of Agriculture. M. L. Floyd.

served in the same length of time as much as 1.325 grams at 40° C. (107.6° F.)—that is, more than five times as much.[1]

Soil, climate, rich and uniform manuring, careful curing and proper fermenting must be combined in order to yield a commercial product of superior quality. The value of tobacco depends probably more largely upon its quality than is the case with any other farm product.

The tobacco seed seems somewhat neglected by nature, since the amount of reserve material to support the young plant in its first stage is exceedingly minute. It takes 21 seeds to weigh 1 milligram; consequently the initial growth is but slow and much in disproportion to the later energetic development, the tobacco after being planted in the field often reaching its full development in forty-five days in Florida. The reserve material of the endosperm of the seed consists, according to Harz, essentially of fat and protein matter, and is, like the 0.6 mm. long embryo, devoid of starch. The young delicate plant soon consumes this small amount of reserve material and is forced to prepare its own organic matter in a much earlier stage than is for instance a corn, barley, or bean plant. Unusual care is required in the seed bed, which if too moist will favor fungous diseases among the young plants. A moderately dry soil, occasionally sprinkled, is preferable.

Much has been written about the proper manuring of the tobacco field. General experience indicates that barnyard manure is here superior to all other fertilizers. An addition, however, of some superphosphate of lime, and carbonate or silicate[2] of potash (5 parts per 1,000 of barnyard manure), and Chile saltpeter (not over 15 parts per 1,000 of the barnyard manure) the last mentioned to be applied in the spring and the other materials in the autumn, is recommended by some. The advantage of the barnyard manure consists in loosening the soil, increasing its absorptive power by formation of humus and yielding up its insoluble nourishing compounds gradually in a soluble condition. It makes, in short, a uniform nutrition of the plant during the entire season more easily possible than a mere mixture of mineral fertilizers can do.[3] The tobacco thus grown is of the best quality and least subject to the mosaic disease.

---

[1] Sand leaves, which are generally poorer in respiration material, produced only 0.568 grains at 42° C.

[2] Sulphate and chlorid are to be avoided.

[3] Of other materials that have been applied with great advantage should be mentioned cotton-seed meal and castor pomace with cotton-hull ashes. The amount of fertilizers applied per acre of a tobacco field varies from 200 pounds to a ton. Nitrogenous manures applied in very large quantities increase the percentage of nicotine and protein and also, naturally, the total yield, but the quality may be injured. Thick ribs and a poor burn have been observed in such cases.

Behrens (Landw. Vers. Stat. 52, 242) calls attention to the fact that the increase of easily soluble salts in the soil, as is the case when merely mineral manures are applied, leads to the formation of thicker leaves. This modified anatomical structure also caused by very dry seasons, decreases the amount of transpiration from the leaves. Such thick leaves require a longer time to cure, and thus the danger of pole burn and other fungous diseases is increased.

A Havana seed plant, after topping and suckering, is generally left to develop about 15 leaves, while the Connecticut seed leaf is allowed to develop but 13, the latter, however, being larger than the former.[1] Of one Havana seed plant with 15 leaves, 10 leaves were found by the writer to average 44 cm. in length and 20 cm. in width, while the 5 largest leaves averaged 52 cm. in length and 24 cm. in width. On another field the length and width of all 17 leaves of one plant were measured and the average taken. The average was—length, 45 cm.; width, 28 cm. An unusually large Havana leaf measured 75 cm. in length and 39 cm. in width. The proportion between the length and width of full-grown leaves varies considerably even on the same field.

Two ripe leaves of medium size each measuring 44 cm. in length and 24.1 and 25.5 cm., respectively, in width, weighed 6.55 and 8.40 grams, respectively, in the dried state. In order to determine the weight for 1 square meter 100 square centimeters were cut from different leaves, partly avoiding the midrib and partly taking it in. The fresh weight varied between 3.01 and 4.12 grams, averaging 3.5 grams in the fresh and 0.595 grams in the dry state. This would give for 1 square meter 59.5 or about 60 grams. It nearly agrees with the result obtained by H. J. Patterson, who found for Maryland tobaccos the maximum average dry weight to be 65.5 grams. According to Behrens the weight of Sumatra tobacco leaves varies between 52 and 90 grams per square meter.[2] Since the quantity of starch differs very much in leaves cut in the morning and those cut in the evening, considerable difference in weight should not surprise us. The figures given above refer to starch-free leaves.

REMARKS ON THE CONTENTS OF THE TOBACCO LEAF.

The epidermis of the tobacco leaf develops partly into noncapitate hairs and two kinds (long and short ones) of capitate gland hairs. The apical cells of the gland hairs contain chlorophyll granules when young and generally in each cell a radiary group of calcium oxalate crystals. Later on the gland hairs contain resin and other matters, and a dilute alcoholic iodine solution stains the contents a deep brown. The dissolved albumin content in the plant juice varies considerably with the age of the leaf. The lower or sand leaves contain, on becoming yellow, but very little or no soluble albumin, while the full-grown green leaves on the same plant are rich in it. This is to be expected, since only the normally green chlorophyll bodies can produce sufficient sugar to make protein production considerable. The "ripe" leaves, however, are richest in soluble albumin. It may also be mentioned that tobacco attacked

[1] In Deli, Sumatra, 22 leaves are left when the tobacco is on good soil, but on poor soil only 14 leaves are left. The leaves in Sumatra reach 42–46 cm. in length and from 31–38 cm. in width. (Van Bemmelen.)

[2] These numbers vary very much from the numbers given by Barth (Landw. Ver. Stat., vol. 39, p. 92) who states that dried coarse leaves may weigh per square meter 200 grams and more. There may be an error in his calculations.

by the mosaic disease contains much less soluble albumin than normal leaves, for an equal surface. The latter give a juice which, upon being heated, forms a large amount of flocculent coagulum; the former, however, hardly more than a turbidity. This is not surprising, since the chlorophyll bodies are affected in the mosaic disease and hence can not furnish a sufficient amount of sugar for an abundant protein formation. The fat content varies considerably, the amount being—other things being equal—probably influenced by the weather, since low temperature will retard growth and respiration more than it does assimilation; hence some sugar that would otherwise have been consumed by respiration may be transformed into fat, if the conditions for protein formation are not all fulfilled at that time. The sugar is the material from which not only the cellulose, starch, fat, and protein, but also the wax, tannin, and resin of the leaves are produced.

The most interest, of course, is attached to the formation of nicotine, which alkaloid, according to Pinner, has to be considered as pyridyl-N-methyl-pyrrolidine. It is probably formed from decomposition products of proteins and plays no further physiological rôle in the plant. The malic acid of the leaf may also participate in the synthesis of nicotine, since nicotinic acid can easily be reached by transformations of malic acid. The object of the nicotine production in the wild plant is possibly to keep off depredating enemies among the insects, but the amount of this poison in young plants cultivated in our climate is too small to kill the insects feeding on the leaves.[1] Even the ripe leaves, richest in nicotine, are attacked with impunity by certain caterpillars, grasshoppers, and the "suck fly," a heteropterous insect (Dicyphus minimus). The nicotine, according to Wizsman-Leyden, is contained especially in the cells underneath the hairs.[2] Adolf Mayer found that the veins contain much less nicotine than the lamina.

The fresh leaves contain relatively but little wax, resin, lecithin, tannin, and calcium oxalate, the latter occurring as a sandy crystalline deposit, especially in mesophyll cells. The oxalic acid, as well as the citric and malic acids of the leaves, is probably an oxidation product of sugar.[3] A part of these acids occurs in the form of a neutral, another part as acid salts.[4] The cell sap, therefore, shows an acid

[1] The amount of nicotine formed depends largely upon climate and weather (cf. A. Mayer, Landw. Vers. Stat. vol. 38, 453 [1891]).

[2] Südd. Apoth. Zeitg., 1898.

[3] According to Kissling the amount of oxalic acid varies in commercial tobaccos between 0.96 and 3.72 per cent of the dry matter; that of citric acid between 0.55 and 8.73; that of malic acid (in form of neutral and also acid salts) between 3.49 and 10 per cent. (Chem.-Zeitung, 1899, No. 1.)

[4] Behrens (Landw. Vers. Stat. vol. 52) found from 5.79 to 9.79 per cent malic acid in form of soluble salts in the tobacco leaf (dry matter) and infers that it is the hygroscopic quality of these salts that keeps the leaves from drying up too easily, which thus preserve a certain softness and elasticity. The more malic salts are present the more "life" is in the finished tobacco leaf. Stored under equal conditions, leaves rich in malic salts may contain 3 per cent more water than leaves poor in them.

reaction. It seems of special interest to determine here the degree of acidity, since the amount of enzyms of importance in the curing and sweating process may be decreased by acids.[1]

ACID CONTENT IN DIFFERENT PARTS OF THE TOBACCO PLANT.

The free acid of the juice was titrated in the usual way by one-tenth normal soda solution and calculated as free malic acid. Although in reality this acid is present as an acid salt and not as free acid, it makes no difference as to the number of unneutralized carboxyl groups, and the data obtained can serve for comparison. The juice was prepared by grinding the objects with the aid of some pure quartz sand and pressing the pulp through thin flannel. The juice of the leaf had to be mixed, however, previously to titration, with an equal volume of strong alcohol to precipitate suspended chlorophyll grains, otherwise the point of neutralization could not be observed with sufficient precision on blue litmus paper, still less distinctly on violet litmus paper. Filtration, after the addition of the alcohol, was not found necessary previous to the titration.

The amounts of free acid in the different organs are, of course, subject to variation within certain limits, according to the atmospheric conditions and the influence of direct sunlight. Thus the writer has observed with the flowers of *Ipomœa triloba* that warm weather with bright sunshine diminishes the acidity, while cool and rainy weather increases it, whereby the blue flowers turn red; and further, the acidity is greater in the morning than in the evening, which the writer also observed in the case of tobacco. The custom of harvesting tobacco on bright, sunny days has therefore a sound physiological foundation.

The following data were observed:

Part of plant.	c. c. $\frac{n}{10}$ soda solution required by 10 c. c. juice	Per cent of free malic acid in juice.
Small roots	0.5	0.033
Pith	.8	.052
Bark	1.4	.092
Midrib of leaf (evening)	1.6	.105
Midrib of leaf (evening)	1.5	.098
Midrib of leaf (morning)	2.1	.138
Lamina of ripe leaf *a*	4.4	.294
Lamina of ripe leaf	4.2	.277
Lamina of young suckers	2.2	.145
Lamina of young suckers	2.4	.156

a Midrib and large side ribs removed.

We learn from these numbers that the least amount of acid is contained in the small roots and in the pith; also that the lamina contain much more than the rib, and that the young leaves contain less than the ripe old leaves.[2]

[1] Certain fungi, as, for example, Oospora Nicotianæ, will grow on fermented tobacco only in the presence of some free organic (malic) acid (Splendore). This shows also in this respect an unfavorable effect of the acidity.

[2] These relations may differ in different plants. Thus Kraus has observed less of free acid in the leaf of *Sempervivum* than in the root.

RIPENING OF THE TOBACCO LEAF.

The ripening process, in a normal physiological sense, refers to the fruit and implies the normal formation of the embryo and the filling up of the reservoirs of the fruit with the proper material for the young growing plant. The ripening of the tobacco leaf on a topped and suckered plant, however, implies an abnormal accumulation of organic matters in the leaves, brought on by preventing their transportation to the forming seeds and shoots or suckers, which would otherwise have consumed a great deal of these substances. The "ripening" of the tobacco leaf is, in other words, not a physiological, but a pathological phenomenon. By the accumulation of nicotine, oxidizing enzyms, and acids a state is finally reached in which the normal deep green color of the chlorophyll grains gives way to a yellowish color. A "ripe" leaf contains per 100 square centimeters an average of 0.164 gram of matter soluble in boiling water, while a young leaf contains only 0.066, the former having, therefore, for an equal surface about 2.5 times as much soluble organic matter as the latter. As to the total weight, a ripe leaf weighs from 1.3 to 1.5, on the average 1.4, times as much as an equal surface of a young leaf of the same plant. It is especially the nicotine and protein compounds that increase in the ripe leaf, a fact of which anyone can soon convince himself by a comparison of the reaction caused by phosphotungstic acid in the juices of ripe and unripe leaves. The amount of water in ripe leaves averages roughly 83 per cent and in young leaves 88 per cent, that is, when compared in nearly starch-free condition after being kept for two days in darkness.

But it is not only the increase (relative and absolute) of reserve materials and of products of metabolism that is brought on by topping and suckering; it is also the enlargement of the leaf surface, which may amount to over 50 per cent above the normal. The suckering exerts these influences to a higher degree than the topping (Behrens). A further influence, due to differences in topping, has been observed, low topping producing thicker leaves than high topping.

An important factor is the proper time for topping and suckering. The suckers must be removed neither too soon nor too late. In the former case, too much protein would be left in the full-grown leaf; in the latter, too much nicotine might be lost from it. Goff observed that in moderate climates the tobacco leaves increased in weight at least to the thirty second day after the topping had been performed. A ripe leaf is recognized by the planter not only by the setting in of a yellowish coloration and a peculiar rough feeling to the touch, but also by the facility with which the lower epidermis peels off and the leaves break ("snap") when folded between the fingers.

As to the so-called "overripe" leaves, they contain, like the young leaves, relatively more water and less organic matter than the ripe leaves. By the stoppage of the functions of the chlorophyll grains, which gradually change in the overripe leaves, new production of

organic matter is prevented, while consumption still proceeds. With the young leaves it is the growth, besides the respiration, that consumes material and prevents its accumulation.

In comparing the undiluted juices of overripe and ripe leaves, great differences can at once be noticed by adding a double volume of alcohol or phosphotungstic acid, the ripe leaves yielding a much more copious precipitate than the overripe ones. The juice of ripe leaves is, further, more slimy and more acid. From the central part of the leaves 100 sq. cm. were cut out of each side of the midrib and ground with some quartz sand and 10 c. c. of water to a fine pulp in a mortar and directly titrated, after the addition of 10 c. c. of strong alcohol. The result was as follows:

	c. c. $\frac{n}{10}$ soda solution for 200 sq. cm. of leaf.	Content of free malic acid in 100 sq. cm. of leaf.
		Grm.
Ripe upper leaf	3.8	0.012
Sand or lower leaf	3.0	.010

From the center of another field, ripe upper leaves and lower or sand leaves of the same plant were collected. The lower leaves were of a lighter green than the upper ones. The juices were prepared as usual, and 10 c. c. titrated. The juice of the upper leaves required 4.2 c. c. of one-tenth normal soda solution, while that of the lower leaves required but 3.2 c. c. Since it is the sugar principally that gives rise to the formation of acid, we should not be surprised at finding more acid in the upper leaves than in the lower, as the production of sugar and starch depends upon the access of light to the chlorophyll bodies.[1]

Well-ripened leaves, rich in oxidizing enzyms and in nicotine, and very rich in soluble matter generally, will yield when normally cured the so-called "gummy" leaves with a well-developed "grain," and after a thorough sweating a fine aroma, while unripe leaves will show injuries after the sweating process and yield, like the sand leaves and overripe leaves, an inferior product. Hence, the single-leaf-curing process would be preferable to the method of curing on stalk, since the overripe, ripe, and unripe leaves are in the latter method harvested together, to be cured under equal conditions.

It is not the object of this report to give an exhaustive critical comparison of these two methods.[2] Where labor is very expensive, the method of single-leaf curing may be out of the question. The same may be said for the priming of the very large leaves of Connecticut seed-leaf tobacco. Here in the removal of the lower leaves at their

[1] In organs free of chlorophyll, as the flowers, the direct sunlight can, on the contrary, exert a diminishing effect on the amount of acid.

[2] The chemical analysis of fully ripe leaves cured after these two methods does not show essential differences. (Behrens.)

ripening stage the upper leaves may easily be broken or lacerated, thus leading to a considerable loss.

The single-leaf curing, a process that seems to grow more and more in favor with the farmers in certain States, takes one-third less time than stalk curing, permits the harvesting of about double as many leaves as the curing on the stalk, gives a more uniform product, and permits the gathering of top suckers, which may form good wrappers.[1] The stalk is here longer in the field and continues to produce healthy leaves from the suckers.

ENZYMOLOGY OF THE TOBACCO PLANT.

The important physiological rôle of enzyms for every organism is well known. Some enzyms are found in all organisms, others only in a few, and some may even occur only in one. Three physiological groups of enzyms can be distinguished: (1) Such as are most intimately and directly connected with the nutritive processes, as diastase and proteolytic enzyms; (2) such as bring on coagulation—the clotting enzyms, as pectase and thrombase; and (3) such as cause oxidation—that is, the oxidases.

It was to be expected from analogy that enzyms of the first and third groups would occur in the tobacco plant, and, since the activity of the enzyms is not only of physiological value to this plant itself, but in this case is also of practical importance to the tobacco planter, it was important to prove their presence beyond a doubt. Two oxidizing enzyms have been shown by the writer to exist in the tobacco plant,[2] and recently a third one has also been observed. This will be described further on.

DIASTASE IN THE TOBACCO LEAF.

The disappearance of starch in the early part of the curing process is due to the presence of diastase. It has been asserted that diastase does not occur in leaves and that protoplasm itself is capable of doing the same work,[3] This appears very improbable, since both starch and protoplasm are insoluble in water. It is, however, somewhat difficult to demonstrate the presence of small quantities of diastase in the juice of leaves, since some can easily be retained by the pressed residue. Brown and Morris have observed that powdered leaves, if directly digested with some starch paste, gave a diastatic action of much greater intensity than was obtained when juice corresponding to that amount of leaf substance was applied.

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[1] This method is practiced extensively by Mr. G. Barnes, of Hatfield, Mass.

[2] Report No. 59, U. S. Department of Agriculture.

[3] Wortman observed that leaves killed with chloroform or kept in an atmosphere of carbonic acid show no decrease of starch, and hence inferred the absence of diastase in leaves; but this is not justified, for several reasons. Recently it has been shown by A. F. Woods that diastase is easily changed by oxidizing enzyms. Furthermore, Vines, and also Jentys, have given new proofs of the presence of diastase in leaves.

The presence of diastase in the tobacco leaf was demonstrated by the writer as follows: Four large healthy leaves were well crushed in a mortar with some sand and pressed. The filtered juice was precipitated with alcohol, and the precipitate, after being washed with alcohol of 90 per cent and pressed between filter paper, was digested with 10 c. c. of highly diluted starch paste at 60° C. (140° F.). The iodine test applied to a drop of the liquid on a white porcelain plate, showed that the starch gradually diminished and disappeared after two hours. Leaves kept for eight days in darkness and near death by starvation did not, when so examined, show any diastase content. This would probably also prove the case with leaves from the curing barn. The destructive effect of oxidase on diastase (Woods) comes into play here.

PROTEOLYTIC ENZYM IN THE TOBACCO LEAF.

The decrease of protein in the tobacco leaf, while curing is going on, can be ascribed only to a proteolytic enzym. The amount of it, however, is probably small, since the coagulable albumin contained in the juice of tobacco leaves decreases very slowly; even after several weeks leaves taken from the barn may show some of it. It may be possible that the oxidizing enzyms injure this enzym, as they do the diastase, and thus prevent an accumulation beyond mere traces in the fresh leaf. Many authors have encountered difficulties in attempting to prove the presence of proteolytic enzyms in green leaves and fruits. One of the causes of this failure may be that blood fibrin, or coagulated egg albumen, has been used for the test; while certain proteolytic enzyms may exist which can easily peptonize dissolved albumen without being capable of dissolving fibrin or coagulated albumen. Indeed, there may exist a great variety of proteolytic enzyms. Thus, Bourquelot and Hérissey have shown an enzym to exist in fungi which is capable of easily digesting casein, while it can not dissolve fibrin. The writer's experiments with casein and fibrin, in attempting to prove the presence of a proteolytic enzym in the fresh tobacco leaf, were not conclusive, no visible solution of these proteins taking place when digested for several days at 40° C. The method of Fermi and Buscaglioni also proved unsuccessful. These authors recommend a gelatin solution that solidifies at the ordinary temperature. The liquid to be tested is, in the presence of an antiseptic substance, left upon the gelatin in the test tube for several days. The presence of even a trace of proteolytic enzyms will soon be indicated by the liquefaction of the gelatin below the line of demarcation. The principal objection which may here be raised is that proteolytic enzyms may exist which can act on gelatin only at a higher temperature—that is, above the temperature 20° to 22°, at which the usual gelatin preparation liquefies by melting.

In the following experiment the test recommended by Märtz was adopted. Ten fresh and 10 starved leaves, of as nearly the same size

as possible, were rubbed with sand to a fine pulp and the juices pressed out. A portion of each of these juices was kept separate as control, while the chief portions were mixed with an equal volume of a solution of albumin. This solution was obtained by pressing the white of an egg through linen, diluting the liquid with fifteen times its bulk of water and filtering. A portion of the albumin solution was also diluted with an equal volume of water and kept for control. All liquids were kept at from 18° to 22° C. in closed test tubes which had received an addition of ether to exclude bacterial development. After nine days the filtered liquid received an addition of some nitric acid and the precipitate formed was left one day to settle. The volume of the precipitate showed a moderate decrease in the juice of the fresh leaves and a considerable decrease (about one-half) in that of the starved leaves; therefore the existence of a proteolytic enzym can not be doubted, but it differs from the ordinary trypsin, inasmuch as it can not attack fibrin and casein under ordinary conditions, while it can attack dissolved albumin.

As to the first-mentioned control cases of the juices which had not received the addition of egg albumin, the soluble albumin originally present as reserve matter in the juice was found fully digested in the juice of the starved, but not yet completely so in that of the fresh leaves.

IS A CELLULOSE-DISSOLVING ENZYM (CYTASE) PRESENT IN TOBACCO LEAVES?

Cytohydrolytic enzyms, especially such as easily attack hemicelluloses, occur in phanerogamous plants and are not identical with diastase, as Newcombe[1] has demonstrated. He found such an enzym in the cotyledons of seedlings of Phœnix dactylifera and of Lupinus albus and confirmed its presence in the malt of Hordeum vulgare.

Parasitic fungi, such as eat through wood, must contain enzyms which dissolve the genuine cellulose with great facility. Various observations, especially those of Dr. Erwin F. Smith on bacteria acting as plant parasites, leave no doubt as to the occurrence of such enzyms also in certain species of bacteria.

The fact that tobacco leaves lose more or less of their original degree of tenacity and cohesion, and even show holes when subjected to sweating in a too moist condition, appears to find a simple explanation in the action of bacteria, which may occur in the presence of too much moisture. But it would have to be assumed that cellulose dissolving bacteria, of which not many kinds are known, are always present whenever too much water is applied to the tobacco. It was therefore of interest to test whether cytase, which has been shown to be present in certain germinating seeds, was also contained in the tobacco leaf itself, or whether it was eventually formed from another enzym in the

[1] Annals of Botany, March, 1899.

process of curing; in other words, whether the abnormal softening of the leaves was accomplished without the action of bacteria. Parts of cured tobacco leaves and of fresh leaves, the latter previously dried at 45° C., were therefore moistened with water and left for twelve days at from 45° to 50° C. in test tubes with as little 20 per cent alcohol as sufficed to cover them. Bacterial development was thus excluded, but not the action of enzyms. Vapor of chloroform in closed flasks was also used in place of the 20 per cent alcohol. The result was that the green leaves (healthy as well as mosaic diseased leaves) did not show any decrease of tenacity, but the cured leaves did, although only to a slight degree. From sweated leaves a concentrated extract was now made at the ordinary temperature, a second portion of leaves being extracted with the first extract obtained, and so on until the fourth portion was extracted with the same water. The concentrated extract thus obtained was saturated with ammonium sulphate, whereby a copious precipitate of proteins of a very dark brown color was formed. This precipitate was freed of most of the adhering salt solution by pressure between filter paper, dissolved in a little water, and in presence of chloroform permitted to act for five days on a small piece of fermented leaf at 50° C. Although bacterial growth was here successfully prevented, the leaf was very much softened and lost most of its former tenacity. Nevertheless, the writer is not yet fully prepared to give a decisive answer as to the nature of the cellulose injuring agency in the sweating leaf.[1]

TEST FOR OXIDASE AND PEROXIDASE IN THE FRESH TOBACCO LEAF.

Although in report No 59 (p. 28) the way of testing for the oxidizing enzyms of tobacco was mentioned, some further remarks on this subject will not be superfluous for those who intend to make further observations on these enzyms. The principal reagent, as has been mentioned, is guaiac resin in absolute alcoholic solution, which gives a blue coloration when oxidase is present and, in connection with hydrogen peroxide, a blue coloration when peroxidase is present.

While the test for oxidase and peroxidase in the stalk and ribs of leaves can be directly applied to the objects themselves, there is some difficulty encountered in the lamina, since the green color of the chlorophyll interferes with the recognition of the pure blue reaction.[2] Furthermore, when the juice is prepared by rubbing the leaf to a pulp and pressing this through flannel, it will contain so many chlorophyll granules in suspension that the juice has to be filtered through filter paper.

[1] Bumke and Wolffenstein have recently found that cellulose is comparatively easily changed, under certain conditions, hydralcellulose being formed. Perhaps a similar action takes place in the sweating leaf when too much moisture is present and the oxidizing enzyms act upon the cellulose walls.

[2] The blue reaction may be distinguished to some extent in the leaf by applying the reagent to the spongy tissue after the removal of the lower epidermis.

This filtering, however, proceeds so slowly that a brown coloration is meanwhile developed by oxidation. By mixing the juice, however, with an equal quantity of 90 per cent alcohol, or by rubbing the lamina in a mortar with an addition of 50 per cent alcohol—whereby proteins and other matters are precipitated—a larger amount of clear filtrate ready for the test is soon obtained.

It is often preferable to dry the leaf at a temperature of from 40° to 45° C., grind it to a fine powder, extract this for a short time with cold water, and apply the tests to the filtrate. It need hardly be mentioned that the juices of the pith or of the main ribs of the leaves can serve directly for the tests. They filter easily and do not darken as readily as the juices from the lamina.

In regard to the guaiac blue, it may be mentioned that it sometimes fades out soon after its formation. This may be due to tannin and other reducing compounds; it seems not to be due to another enzym.

ARE THE TOBACCO OXIDASE AND PEROXIDASE KINDS OF PROTEINS?

These enzyms belong neither to the coagulable albumins nor to the nucleoproteids. The latter are precipitated by dilute acids, but since the juice of green tobacco leaf is of moderate acid reaction, it can not contain ordinary nucleoproteids in solution. Even upon the addition of 1 per cent of acetic acid to the juice, no nucleoproteids are precipitated. If, as Spitzer has recently claimed, the peroxidase of mammalia is a nucleoproteid, we must assume a considerable difference between the peroxidase of mammalia and that of tobacco, and probably of other vegetal sources.

The following tests show, further, that oxidase and peroxidase do not belong to the coagulable albumins. The freshly expressed and filtered juice of the tobacco leaf yields upon heating to 54° C. a copious coagulum of albumin, while the filtrate therefrom gives a strong reaction for oxidase and peroxidase. On further heating this filtrate to 65° C. for a second, another but a very insignificant coagulation is observed. The filtrate of this precipitate still yields both reactions, but it may now be heated to the boiling point without giving a coagulum. Further, when green tobacco leaves are dried at a temperature of 50° C., pulverized, and extracted with ten times the weight of cold water for thirty minutes, a filtrate of weak acid reaction is obtained which contains mere traces of albumin. Nevertheless, it gives the peroxidase reaction with guaiac, even after heating for a second to 85° C. (not to 90° C.). This solution was heated for a few seconds to a temperature of 66° C. and the slight turbidity removed by filtration, after which the cooled filtrate was saturated with ammonium sulphate, whereby a dark precipitate was formed. This contained the oxidase and peroxidase and a part of the brown coloring matter of the original extract, while the filtrate yielded no trace of the guaiac reactions. After being freed as far as possible from the adhering liquor, by pressing between sheets of filter

paper, the precipitate was easily dissolved in water. This solution not only gave intense reactions for oxidase and peroxidase, but yielded also a precipitate with alcohol and gave Millon's reaction; the biuret reaction, however, was impeded by the dark color of the liquid. Both oxidase and peroxidase, therefore, seem to have the main character of albumoses. It follows, then, that the animal oxidase must differ from the vegetal, since Abelous and Biarnès believe the former to be a kind of globulin.[1] When the aqueous extract of dried tobacco leaves is neutralized, a small amount of precipitate is obtained, containing, among other things, lime salts, and a part of the oxidase mechanically carried down.

BEHAVIOR OF OXIDIZING ENZYMS TOWARD INJURIOUS COMPOUNDS.

The supposition might be entertained that oxidase and peroxidase are chemically closely related, the latter representing, perhaps, a derivative of the former. Peroxidase, however, resists not only a higher degree of heat than oxidase, but also is less easily injured by poisons.

In comparing tobacco oxidase with tobacco peroxidase in their behavior toward noxious compounds, a solution of the former was prepared in the manner formerly described,[2] and its reaction compared with the oxidase reaction in fresh tobacco juice after addition of various solutions of known strength.[3] Before making the tests care was taken to have a neutral or only slightly acid reaction, as guaiac blue is easily altered by various influences, and especially by mineral acids and alkalies. Also, certain organic substances of comparatively weak acid qualities, like tannin, can prevent the reaction. Acetic acid, in higher concentration than 2 per cent, interferes with the production of the guaiac blue.

The following table shows the results obtained:

Reagent.	Oxidase.	Peroxidase.
Acetic acid, 3 per cent	Killed within 5 hours	Reaction much weaker after 24 hours.
Acetic acid, 1 per cent	Killed within 24 hours	Reaction weaker after 24 hours.
Hydrochloric acid, 0.5 per cent.	Killed immediately	Killed immediately.
Sulphur dioxide, 0.25 per cent.	....do	Unchanged after 24 hours.
Ammonia, 0.3 per cent *a*	But little altered after 24 hours.	Unaltered after 48 hours.
Potassium hydroxide, 0.3 per cent. *a*	Considerably decreased after 2 days.	Do.
Free nicotine, 1 per cent	Killed in 24 hours	Do.
Formaldehyde, 5 per cent	....do	Do.

a In these cases the fresh juice was neutralized before adding the above percentage.

[1] Compt. Rend. Soc. Biol., vol. 49, p. 493.

[2] Report No. 59, U. S. Department of Agriculture, p. 29.

[3] A colorless solution of the tobacco oxidases can not be obtained from the lamina of the tobacco leaves, since the juice turns brown very soon, but it may be obtained from the midrib by grinding it, expressing the pulp, and filtering the liquid. By heating a moment to 65° C. (149° F.), the albuminous matters coagulate and a clear, colorless filtrate is obtained which turns yellow but slowly.

It may be added that ammonium oxalate (5 per cent) had no deleterious effect upon oxidase after two days; but nicotine tartrate in a 5 per cent solution, and quinine acetate in a 0.5 per cent solution, seemed to damage the oxidase after four days, although but very little.

KILLING TEMPERATURE OF OXIDIZING ENZYMS.

The temperatures thus far observed which render enzyms inactive are not constant under all conditions; the acidity of the plant juice, the degree of dilution, the duration of the heating, and the presence of certain salts have a modifying influence on the height of the temperature at which the change to the inactive modification takes place. It is to be regretted that authors have not always mentioned the conditions and the duration of the heating. The oxidase of the stalks of the sugar cane is killed at 60° C. (140° F.), the peroxidase of it at 95° C. (203° F.), according to Raciborski. Tyrosinase, an oxidase easily oxidizing tyrosine to a dark substance, is injured at 50° C. (122° F.) and killed below 70° C. (158° F.), according to Bertrand. Laccase, an oxidase of widespread occurrence, is killed at 63° C. (145.4° F.). Oenoxidase loses half of its oxidizing power at 72° C. (161.6° F.) within four minutes, and at 55° C. (131° F.) in one and one-half hours. The oxidase of mammalia is killed at from 80° to 85° C. (Abelous and Biarnès.)

The influence of the duration of the heating is shown by the following test. The killing temperature of the oxidase in the juice of the tobacco leaf was repeatedly found to be from 66° C. to 67° C. when the juice was diluted (one part dried leaf to twenty parts of water) and the solution heated for three minutes. But in heating it for a second only a much higher temperature may be endured. Certain salts, as ammonium sulphate, and also traces of free ammonia, increase the resistance, while acids, even in small quantities, decrease it. The juice of the midrib contains less acid than that of the lamina, and consequently it takes a temperature several degrees higher to kill the oxidase in the former than in the latter, but on being neutralized the latter may be safely heated for a moment to 75° C. The addition of alcohol decreases the power of resistance. Thus an addition of 33 per cent of alcohol to a neutralized solution of oxidase will depress the killing temperature about 2° C.

The following tests were made with peroxidase: Fresh tobacco leaves were ground, with the addition of some sand and a little water, and the pulp expressed. The residue was now left for some hours in contact with water to which 0.5 per cent acetic acid was added, and expressed again. The filtrate thus obtained was exactly neutralized with dilute caustic soda. It gave only a very faint reaction for oxidase, but an intense reaction for peroxidase. To one portion (20 c. c.) was added one-half its volume of absolute alcohol; to another 10 per cent of ammonium sulphate. Upon heating in a water bath it was found

that the peroxidase in the alcohol mixture was killed at a temperatu of 70° kept up for a few seconds, while in the mixture containing t ammonium sulphate the enzym was not killed after heating the mixtu for a short time to 93° C. In the control solution the enzym was kill at 87° C. after three minutes.

Grüss encountered in some vegetable objects an oxidase that resis the action of boiling absolute alcohol. He designates it as γ-oxidas

That such an oxidizing enzym exists which can resist even boilin absolute alcohol might appear strange. But when we consider th the action of absolute alcohol consists in the first place of deprivin the objects of water, and, further, that dried enzyms resist a muc higher temperature than enzyms in the moist or dissolved state, th observation loses its singularity. It may here be pointed out th recent investigations of bacteriologists have proved that certain kind of bacteria also succumb much more easily to alcohol of 50 per cen than to absolute alcohol. Protoplasm of a high density which ca resist drying is much less accessible to poisonous actions when dry tha when moist.[1] The writer has also observed that the oxidase in th tobacco leaf resists a higher temperature when the leaf is itself warme with some absolute alcohol than when the dilute leaf juice is. How ever, a prolonged contact with absolute alcohol will doubtless kil the oxidase. Here, also, the peroxidase resists much better than th oxidase.

CAN THE AMOUNT OF OXIDASE BE INCREASED BY SPECIFIC MANURING?

Since Bertrand and Villiers have found some manganese is a regula ash constituent of the oxidases[2] and since it seems justifiable to attribute to that circumstance an essential influence on the specific actions of the oxidases, it was of some interest to try to discover whether an increase of manganese in the soil would lead to an increase of the oxidizing enzyms in the tobacco plant. Therefore a 0.1 per mille solution of manganese sulphate was repeatedly used to water some tobacco plants, each of which received altogether 0.6 gram of that salt.[3] The examination of the ripe leaf, however, showed no noticeable increase of oxidase and peroxidase on colorimetric comparison with the plants not so treated. Possibly the soil contained a sufficient amount of manganese for the formation of the normal maximum amount of these enzyms.

A THIRD OXIDIZING ENZYM IN THE TOBACCO PLANT.

The unfiltered juice of fresh tobacco leaves energetically decomposes hydrogen peroxide with evolution of oxygen. The clear filtrate

[1] Also seeds resist a higher temperature when dry than when soaked in water.

[2] Compt. Rend. vol. 124, pp. 1032, 1349, 1355.

[3] These experiments were conducted by Dr. E. H. Jenkins on the experimental field in Poquonock, Conn.

btained from the turbid juice shows this property only to a very mall degree while the suspended matter acts as powerfully as the nfiltered juice. It is easy to prove that neither particles of the living rotoplasm of the leaf cells nor an admixture of bacteria are the cause f this action, since contact with chloroform does not essentially alter hat power after a day. Certain observations of the writer, not agreeing with the prevalent views, led him to a further examination of this henomenon. Several authors have observed this property with arious organisms and ascribed it to the known enzyms contained in hem, following Schoenbein,[1] who expressed this opinion in the year 863.

This view was not even doubted after it was shown by Jacobson that this property of the common enzym preparations may be destroyed without injury to the true enzym nature, i. e., to the specific activity.[2]

While ptyalin, pepsin, and myrosin preparations gave Jacobson only small quantities of oxygen by decomposition of hydrogen peroxide, emulsin, pancreatin, and diastase, in freshly prepared condition, yielded considerable quantities. Jacobson proved that by heating to a certain temperature, by "exhaustion of the catalytic power" (of decomposing hydrogen peroxide), by dilute acids, and by various poisons, this property could be either destroyed or considerably weakened without the true enzym character being materially injured.

Since it seems very doubtful that the molecule of an enzym can be changed to a great extent without destroying the specific property, the writer finds it much more natural to explain the observations of Jacobson by the presence of another enzym, to which this decomposing action on hydrogen peroxide is due. In the preparations of the common enzyms the presence of other enzyms as impurities can not be surprising. The further observations of the writer have confirmed this view. A full account will be given later in a separate bulletin. Here it may suffice to sum up the main results:

1. The property of developing oxygen by decomposition of hydrogen peroxide is due to a separate enzym.

2. This enzym, to which the name catalase may be given, occurs in two modifications, one insoluble and one soluble in water. They may be distinguished as α and β catalase. The insoluble or α catalase is probably a combination of the enzym with a nucleoproteid.

3. This enzym is killed at 72–75° C. (161–167° F.). It is an oxidizing enzym, since it easily produces quinone from hydroquinone. It does not produce guaiac blue from a tincture of guaiac, not even in the presence of some hydrogen peroxide; hence it differs essentially from the ordinary oxidase and peroxidase.

4. The insoluble modification is soluble in dilute alkaline liquids.

5. In the curing process of the tobacco leaf there is a small increase

[1] Journ. Pract. Chem. vol. 89, p. 326.

[2] Jacobson, Zeitsch. Physiol. Chem. vol. 16, p. 340, 1892.

of the soluble modification, probably formed from the insoluble. This increase is larger in the sweating process.

6. This enzym is the most durable of those in the tobacco leaf under ordinary circumstances, since it occurs in tobacco even over 6 years old, in which no trace of other enzyms, not even of the peroxidase, can be found.

7. It is certainly an important factor in the heating up of the tobacco pile, as recent experiments with fermenting tobacco have shown.

The general occurrence of this enzym in plant as well as in animal cells suffices to indicate a highly important physiological rôle. It is probably intimately connected with the process of respiration. The following two hypotheses as to its function appear the most probable to the writer:

1. Since many oxidative processes lead to the formation of hydrogen peroxide as a by-product, it is important that such a poisonous by-product be at once destroyed when accidentally formed in the cells in the course of the respiratory oxidations.

2. This enzym may have the office of loosening affinities in fatty acids and sugar in order not to tax the chemical energy of the protoplasm itself too heavily when these compounds are consumed for the purpose of respiration.

REMARKS ON THE MOSAIC DISEASE OF THE TOBACCO PLANT.

The mosaic disease, in the Southern States called "frenching" and in the Northern States "calico," "brindle," and "mongrel" disease, is of special pathological interest. For a discussion of the causes, theories, and scientific investigations on the development of this disease the reader is referred to a special and extensive bulletin by Albert F. Woods, of this Division, which will make its appearance at no distant date. In this place will be mentioned chiefly a number of observations made by several planters.

The disease is easily recognized by the contrast of the dark-green regions, mostly near the veins, and the light-green regions of the lamina. The former, being better nourished on account of containing more chlorophyll than the latter, grow faster. This causes the leaves to curl and assume a wavy shape, like corrugated iron, rendering the leaves worthless for wrappers. Highly diseased leaves have to be entirely discarded. The disease sometimes affects as much as 10 per cent of the plants of an entire field. At times it attacks only a few leaves of a plant, and at other times the entire plant is affected. Broad-leaf tobacco is asserted to be more liable to the disease than Habana seed tobacco. The annual damage thus done in the United States is estimated to be more than a million dollars.

Various causes seem to create a tendency to the disease. Some act in the seed bed, some depend upon the mode of planting in the field,

and others seem to depend upon changes in the weather.[1] Solely a surplus amount of water in the soil, involving a deficiency of root aeration, does not produce the mosaic disease, as the writer observed. In a field one corner of which was continuously moist, the plants were of a uniformly yellowish-green all over, and they were only about half the height of the healthy plants, but there was no trace of symptoms of mosaic disease visible.

The diminished amount of chlorophyll in mosaic diseased plants, leading to a diminished production of organic matter, soon shows its effect in the more or less retarded development of the whole plant. There is also less coagulable albumin and less acid in the leaves of the diseased plants than in those of healthy ones of about equal age. The juices were titrated with one-tenth normal soda solution and the acid calculated as malic acid.

The following amounts of malic acid were found in a diseased and in a healthy plant:

	Diseased plant.	Healthy plant.
	Per cent.	*Per cent.*
Pith	0.033	0.033
Midrib of leaf	.048	.105
Lamina of leaf *a*	.210	.277

a After removal of midrib and large side ribs.

The relative amounts of oxidizing enzyms also are different in diseased and healthy leaves. The observations of the writer agree essentially with those of Woods.[2] Not only the midrib and the pith, but even the dead spots of the diseased leaves contain very much oxidase, while the lamina contains much more peroxidase than that of healthy leaves. The writer had occasion to observe tobacco fields, just before harvesting time, in Connecticut and Massachusetts, and was surprised at the great differences in the extent of the disease even on neighboring fields. Some planters entertain the belief that a too extensive use of mineral fertilizers favors the disease, and, indeed, those fields had the least number of diseased plants which had received chiefly organic manure. Mr. Du Bon, of Poquonock, Conn., whose crop of Habana

[1] One cause may be an insufficient distribution of the manuring material. A tobacco grower at Poquonock set his plants in a field in which one inch of earth covered the cotton-seed meal employed as manure, the latter not being uniformly mixed with the earth. On further development more than 50 per cent proved calico plants.

[2] Paper read before the American Association for the Advancement of Science at Columbus, Ohio, August, 1899. Other papers on this disease have been published by Dr. Wm. C. Sturgis, Conn. Agr. Exp. Sta. Report for 1898; further by Adolf Mayer, Landw. Vers. Stat., vol. 32 (1886); by Beijerinck, and by Iwanowski, Centr. Bakt., vol. 5.

seed tobacco was in excellent condition, had applied per acre the following amounts of fertilizers in the drill:

5 cart loads horse manure,
20 hundredweight of cotton-seed meal,
500 pounds of "dissolved bone black,"
500 pounds cotton-hull ashes, and every other year
300 pounds of lime.

On a field near East Hartford, Conn., many more calico plants were to be seen than on another field on the opposite side of the road—on the former about 8 to 10 per cent, on the latter only about 3 to 4 per cent. This difference might be ascribed to differently manured seed beds or to the different manuring in the field. Both farmers applied horse manure—the first, 5 cart loads to the acre; the second, 9 cart loads to the acre. The former also used 10 hundredweight of bone dust, while the latter applied 800 pounds per acre of the following mixture:

150 pounds of ammonium sulphate,
450 pounds of potassium sulphate,
640 pounds pulverized bone and meat,
600 pounds of "dissolved bone black."

The latter had therefore applied not only much more horse manure to his field, but also more of the easily accessible phosphoric acid and more potash than the former.[1]

Mr. Du Bon, a good observer, reported to the writer the following:

The calico disease may appear even in the seed bed, especially when it is too rich in nitrogenous manure, but the first two or three leaves of the attacked plants are generally normal. Fresh soil that has never served for raising crops does not produce the disease in the seed bed nor does an excess of moisture, but too high temperature is likely to produce it. Yellow plants, stunted in the seed bed by cold weather, never show mosaic disease in the field. In one case it was observed that an acre and a half planted with such yellow plants did not show a single calico plant, while the neighboring acres, planted with vigorous seedlings, developed a great many. Very vigorous plants that had been manured heavily with castor pomace and were looking very well showed much calico later on.

The disease is not easily propagated through the soil of the field. Even twin plants may be found where one is much attacked and the other bears hardly a trace of the disease.[2] Near Poquonock fields have been used for twenty-five years uninterruptedly for the culture of tobacco, and upon this land thoroughly healthy crops are now produced, although formerly the disease was often observed. One year, on a piece of land that contained 12,000 plants, 3,200 calico plants were cut out with a hoe when the plants had reached about 2 feet in height. The following year hardly half a dozen calico plants were noticed on that same plot, but these plants came from a seed bed containing new soil. The great influence of the growth in the seed bed on the

[1] Koning (Zeitschrift für Pflanzenkrankheiten, 1899, p. 65) asserts that manuring with kainit and Thomas phosphate diminishes the extent of the disease.

[2] This fact seems to be in contradiction to the behavior of the plants in the seed beds. A satisfactory explanation is wanting.

later development of the disease is shown by the following observation of Mr. Du Bon: "It happened once that in a portion of a field every other plant was a calico plant and the alternating ones were healthy plants. This remarkable circumstance found its explanation in the fact that in the process of machine planting two baskets were used containing the plants of two different seed beds, one bed being in a condition to favor the disease, the other containing new soil. Two planters worked here at the same time. The neglect of proper precaution in taking the young plants from the seed bed may create a tendency to the disease." In this connection Mr. Barnes, of Hatfield, Mass., related the following: "Young plants were taken from the same seed bed by two different farmers, and, although the soil of the fields was the same, one farmer had many calico plants in his field and the other had almost none. Inquiry revealed the fact that one farmer took the plants from the seed bed when it was quite dry, the other when it was well moistened. In taking the plants from a dry bed one can not help lacerating the roots, while from a well-moistened bed the roots may be withdrawn in an almost intact condition. Lacerated roots do not generally develop again to such a vigorous state as is required by the quickly growing tobacco plants."

For the prevention or diminution of the disease, Mr. Du Bon recommends keeping the plants in the seed bed not too warm and also changing the seed bed. Beds that produce the disease might be grown over for one year with grass, in order to put them in proper condition for the production of healthy tobacco plants. While many planters seem convinced that the diseased plants can not recover, others claim that by hoeing and stirring the soil well the disease may be cured in the initial stage. Mr. Barnes, of Hatfield, Mass., claims to cure the disease by lifting the whole plant a little from the ground. In both cases a better aeration of the soil is reached. The writer is not prepared to confirm or contradict these statements.

OBSERVATIONS ON CURING.[1]

INTRODUCTION.

The curing period is a time of continuous anxiety for the tobacco planter. Too dry weather stops all changes in the leaves, particularly the development of the proper color, while too moist weather, especially at a temperature above 24° C. (75° F.), favors the disastrous pole burn. The great desire of the tobacco planter to become entirely independent of the weather by such improvements in the barn construction as will permit the proper regulation of the temperature and moisture is therefore reasonable.

The general introduction of an ideal tobacco barn can be only a question of time. If the tobacco is becoming too dry, steam should be turned into the building; and if it is becoming too moist, dry heat

[1] These observations were made with leaf cured on the stalk.

should be applied. An agricultural journal describes such a barn as follows:

The barn is what is called a "three-bent" shed. There are three rows of beams, one through the center and one on either side. A 2-inch steam pipe follows the outside beams around the shed. This is believed to be sufficient to supply the necessary heat to the whole building. The tobacco in the extreme outside of the shed rarely suffers from the pole sweat. The tobacco through the center, and especially that low down, is always the worst affected, and the pipes are arranged to throw the most heat into that part of the building. If the experiment proves a success in preventing pole sweat, the time is soon coming when artificial heat will be used entirely in curing tobacco, for the even temperature and moisture that can be obtained are just what is needed for a perfect cure.

As the curing proceeds an alternating change from the moist to the dry condition of the leaves takes place, according to the atmospheric conditions. Practical experience has proved that a frequent change of this kind is desirable.[1] This agrees also with the theoretical inference. There is more oxidase in the ribs than in the mesophyll, and by the alternate drying and moistening the evaporation from the surface causes a current of juice to pass from the ribs to the mesophyll cells. This migrating juice finally distributes most of the oxidase from the bundle sheath and sieve tissue uniformly through the leaf. It is therefore desirable to have the ribs keep alive much longer[2] than the rest of the leaves, since dead and dry ribs would not support the process indicated.

As long as all the cells of a leaf are alive a current of organic matter—especially sugar, and also to a small degree, amido compounds—takes the opposite direction, namely, from the lamina to the ribs. Gradually this function stops, since a state of starvation sets in when the starch, in the form of sugar, has been transported to the stalk and consumed by respiration. The decrease of soluble albumin in the curing process is much slower than the decrease of starch. Even after a fortnight a moderate amount is left, and with single cured leaves, even after four weeks, some traces of it were found in the tissues.

DECREASE OF ACIDITY.

It is an interesting fact that the acid reaction decreases in the lamina as the curing proceeds, as shown by the following table. For 200 sq. cm. there was required the following amounts of one-tenth normal soda solution:

Date.	Uppermost leaves.	Lower leaves.
	c. c.	c. c.
August 1	3.8	3.0
August 8	3.3	2.3
August 14	2.5	1.8
September 26	1.7	.9

[1] Report No. 62 (p. 12), U. S. Department of Agriculture, by Marcus L. Floyd. This report also contains views on the best construction of the usual barns.

[2] The midrib may remain alive for three weeks and over.

At the end of the curing process the amount of free acid for a given surface was therefore reduced considerably.[1] A portion of the acid may have passed into the stalk, another portion may have been completely oxidized, and another may have been neutralized by ammonia formed in the destructive action of oxidizing enzyms on nitrogenous compounds. In the subsequent sweating process the liberation of ammonia is more energetic, and neutralizes the rest of the acid. The decrease of acidity in the curing process is of practical importance, since the following sweating process will set in with sufficient energy only when the reaction is nearly neutral. The practice of the tobacco manufacturers in Florida of applying a spray of ammonium carbonate solution when the "heaps will not heat up well" is therefore in accordance with the scientific inference.

BEHAVIOR OF THE OXIDIZING ENZYMS IN THE CURING PROCESS.

In a normally conducted curing process, whether curing single leaves or curing on stalk, the oxidase and peroxidase are well preserved. This is not the case under conditions unfavorable to a normal curing. The oxidase especially loses its active character more or less. Flue curing seems just as injurious[2] as prolonged moist weather. The acidity in the leaves is, according to the writer's observation, generally too weak to cause injury; but the occasional entrance of too much sunlight into the barn may diminish the oxidase in the exposed leaves. Reynolds Green, and Brown and Morris have shown that enzyms, as, for example, diastase, are injured by exposure to direct sunlight, while with regard to the action of water it has been shown by Laborde that a gradual destruction of oenoxidase takes place within twelve days by self-oxidation when it is dissolved in water and exposed to air. There can hardly be any doubt that much water retained for a certain time in the curing leaves of the barn will favor self-oxidation of the tobacco oxidase. This is also shown by the following test.

A large upper leaf was placed in a covered glass cylinder containing some water, to insure an atmosphere saturated with water vapor. After being kept in darkness for a week at from 22° to 28° C., comparison with a normal leaf showed less oxidase in the parenchyma of the leaves so treated than in that of equally old fresh leaves of the same plant, while with the veins the difference was not so marked. On the other hand, no decided decrease of peroxidase could be noticed.

[1] In the pith and bark no decrease of acidity, but, on the contrary, a slight increase was observed during the first two weeks of curing. Further it may be mentioned that the acidity seems to decrease more slowly when the leaves are single cured than when cured on stalk. Only one test was made, however, in regard to this.

[2] Flue curing is mainly used in the curing of the bright yellow tobacco of Virginia, Tennessee, and North and South Carolina. The temperature reached thereby—71-79° C. (160–175° F.)—is detrimental to the oxidase. Such tobacco, however, is not subjected to sweating.

Furthermore, according to Mr. Marcus L. Floyd, it is a known fact that tobacco too long "in case" because of prolonged moist weather will sweat but very imperfectly. The poorly sweated crop of 1898 in Connecticut also showed much "canker" and "pole burn," conditions favored by too moist weather.

When it happens that tobacco does not sweat well, or even not at all, it may be too acid or may have lost its oxidizing enzyms through irregularities in the curing barn, or it may be too poor in the proper oxidizable material. The writer was assured by tobacco growers of Connecticut and Massachussetts that tobacco grown in very dry years is incapable of sweating; 1871 was such a year. Even the transportation of the tobacco to the West Indies and back, an experiment tried by Mr. Barnes, of Hatfield, Mass., to enforce a natural sweat, did not change the rank smell of the cured to the aromatic odor of sweated tobacco.

The writer was informed in Lancaster, Pa., that the crop raised there in 1881 required nine years to reach the proper quality by means of the natural sweat. Here probably a gradual oxidation without oxidases has produced finally a result similar to that reached in a short time in presence of the oxidizing enzyms.

Since it is the energetic oxidation in the sweating process that yields a cigar leaf of superior quality, it must form one of the principal aims of a tobacco farmer to preserve the oxidizing enzyms while the tobacco is curing in the barn. In the process of sweating, however, there is generally a gradual decrease of oxidizing enzyms going on, the high temperature favoring not only the action of these enzyms on oxidizable material, but also the oxidation of the enzyms themselves. Practical experience long ago found it necessary to take apart and rebuild the fermenting piles as soon as the temperature reached about 60° C. (140° F.). Indeed, if the temperature be allowed to rise much higher there would be a rapid decrease of oxidase, and all the improvements hoped for would come to a premature end.[1] The relative amount of water in the fermenting piles or cases will also exert an influence. The peroxidase suffers less than the oxidase, but the former is probably of very much less importance than the latter in the sweating process. Investigations on this point will be carried on at some later time when occasion offers.

TESTS FOR OXIDASE AND PEROXIDASE IN CURED AND FERMENTED TOBACCO.

In regard to the tests for these enzyms it must be pointed out that from the absence of oxidase in a tested sample it does not necessarily follow that all of the leaves from the same curing barn would be

[1] A full account of the temperature changes in fermenting piles of cigar leaf tobacco is given in Report No. 60, U. S. Department of Agriculture, by Milton Whitney and Thomas H. Means.

devoid of it. It may be that the leaves tested came from near a barn door which was perhaps frequently opened, thus freely permitting the destructive action of the sunlight. Therefore in controlling a curing crop in the barn leaves should be tested not only from near the wall, but also from the more central part of the barn.

The test was at first made in the following manner: The tobacco leaf was deprived of the large ribs, and after drying at a temperature of 40° C. (104° F.) was very finely pulverized. One gram of this dry powder was mixed with 20 c. c. of water and left to stand for five hours in an Erlenmeyer flask at the ordinary temperature. To 10 c. c. of the filtrate a few drops of an alcoholic solution of guaiac resin were added and the mixture was left to stand for ten minutes, with moderate shaking. A blue coloration indicated the presence of oxidase. Since, however, the brown color of the tobacco extract is often so dark that it interferes with the recognition of a weak blue reaction, it was found preferable in such cases to pour guaiac tincture cautiously on the surface of the tobacco extract, avoiding a thorough mixing. The blue color will soon appear as a ring on the surface of contact of both liquids. If, however, no blue coloration appears, a few drops of peroxide of hydrogen are added. A blue coloration in this case is due to the presence of peroxidase. In order to test for the peroxidase in presence of the oxidase in the tobacco extract, it is necessary to heat the liquid for three minutes to 70°C. (158° F.) in order to first kill the oxidase before the test for the peroxidase is made. Guaiac solution in presence of peroxide of hydrogen is now left to act on the cooled solution. The blue reaction for peroxidase sets in at once.

Some additional remarks may be made on the tests with guaiac resin. A solution of guaiacum resin is prepared by dissolving at the ordinary temperature 2 grams in 100 c. c. of absolute alcohol. This tincture must be kept cool and in the dark, and be renewed from time to time, since the active principle, the guaiaconic acid, is otherwise gradually oxidized. Old tincture will soon turn bluish on addition of hydrogen peroxide alone. Attention must be paid to the reaction of the liquid to be tested, which must not be alkaline but neutral or slightly acid, and also to the quality of the resin, since worthless kinds exist in the market. A normal resin must yield an intense blue color with highly dilute nitrous acid. Only the interior parts of transparent pieces of guaiacum resin should be selected for preparing the tincture of guaiac. It is of no particular advantage to use the guaiaconic acid, instead of the resin itself.

An attempt has been made to disqualify guaiacum resin as a reagent for oxidizing enzyms on the ground that nitrous acid, ferric chloride, and other oxidizing mineral compounds also yield a blue reaction. Such objections are groundless when fresh organized tissues are under investigation. Other oxidizing influences are easily recognized by control tests, which the careful worker will not omit to make. The

assertion that albumin and gelatin give the reaction is erroneous. On the contrary, egg albumen impedes or prevents the oxidase reaction on guaiacum, as does also much tannin. It may be added here that among other substances silver nitrate also yields a blue coloration, especially in presence of a very small amount of ammonia. Such blue reactions are not restricted to certain limits of temperature as the reactions of oxidizing enzyms are.

Still more attention to control tests must be paid when materials which are not fresh are to be tested; for, while the fresh tobacco leaf never contains nitrites, sweated tobacco may contain them. This must be considered when the tests are made with sweated tobacco. (See on this point also page 55 of this report.)

The following tests were made with samples, not collected personally, but received by mail.

Tobacco cured but not sweated.

A.—SAMPLES FROM MARYLAND.

[The samples were grown in 1898 on the farm of the Maryland Agricultural Experiment Station. Only the last mentioned was from another locality.]

Date.	Sample.	Oxidase.	Peroxidase.	Remarks.
1899.				
Mar. 13	Connecticut seed leaf....			
	(a) Lowland plot	None	Moderate	
	(b) Upland plot	.....do	Trace	
13	Habana seed	Moderate	Much.....	Cured without artificial heat.
13	Sumatra seed	Less than Habana..	.....	
13	Vuelta	None	Much.....	
13	Pardidos	Moderate	.....do	
18	Maryland broad leaf.....	Slight	Moderate	
18	Virginia	Moderate	Intense	
18	Sumatra seed	None	Moderate	
18	Connecticut broad leaf...	.....do	Trace.....	All subjected to the flue-curing process.
18	Habana seed	.....do	Moderate	
18	Pardidos	.....do	.....do	
Apr. 4	Maryland tobacco	.....do	.....do	

B.—SAMPLES FROM KENTUCKY. (CROP OF 1898.)

Mar. 13	White burley lugs.....	None	Moderate	Single-leaf cured.
13	.....do	Moderate	Much.....	Cured on stalk.
20	Burley grade red leaf....	None	Little.....	Do.

C.—SAMPLES FROM PENNSYLVANIA. (CROP OF 1898.)

Mar. 20	Pennsylvania Habana seed.	Moderate	Much.....	Seed wrapper.
20	Habana seed	Trace.....	Moderate	Seed filler.
20	Pennsylvania seed leaf..	Moderate	.....do	Wrapper.
20	Seed leaf.....	.....do	.....do	Filler.

Tobacco cured but not sweated—Continued.

MISCELLANEOUS SAMPLES.

Date.	Sample.	Oxidase.	Peroxidase.	Remarks.
1899.				
Feb. 23	Wisconsin tobacco (Soldiers' Grove).	None	None	
24	Florida Habana seed (Quincy).	Much	Much	Crop of 1898.
Aug. 13	Hatfield, Mass	do	do	Single-leaf cured (1898).
Sept. 23	Poquonock, Conn	do	do	1899 crop, stalk cured.
Oct. 20	Ada, Tex	None	Trace	1899 crop. This sample had white veins.
20	do	do	Moderate	This tobacco was cut after being "drowned or scalded," [a] and was stripped before it was completely cured.
Dec. 12	Raleigh, N. C	do	Trace	Was fine cured; crop of 1899.
Oct. 18	Elmira, N. Y	Moderate	Much	Medium weight and color; cigar type; crop of 1899.
18	do	do	do	Dark, heavy; cigar type.
18	do	Trace	do	Light weight and color; cigar type.
18	Virginia	Little	do	Dark, heavy; plug type.
18	do	do	Moderate	Medium dark; crop of 1899.
18	do	Trace	Much	Light weight, dark.

[a] This drowned or scalded state is produced when after several days' heavy rain very warm and sunny days follow; the leaves soon wilt.

Tobacco, cured and sweated.

A.—SAMPLES FROM KENTUCKY. (CROP OF 1898.)

Date.	Sample.	Oxidase.	Peroxidase.	Remarks.
1899.				
Mar. 7	Tobacco from Hopkinsville, Ky.	None	Trace	New-ground tobacco; planted May 14; cut Aug. 10; fired lightly; bulked Nov. 21.
7	do	Slight trace	Moderate	New-ground tobacco; fired heavily, bulked later.
7	do	do	Much	Old-ground tobacco; fired heavily; bulked Dec. 10.
7	do	do	do	Same as former, but bulked later.

B.—SAMPLES FROM OHIO. (CROP OF 1898.)

1899.				
Sept. 24	Zimmer Spanish	None	Trace	
24	do	do	Moderate	

C.—SAMPLES FROM CONNECTICUT. (CROP OF 1898.) [a]

1899.				
Sept. 21	Gastonbury broadleaf	None	None	Light wrappers.
21	South Windsor broadleaf.	do	Much	Do.
21	East Windsor Hill broadleaf.	do	Trace	Do.
21	South Windsor broadleaf.	do	Much	Dark wrappers.
21	Windsor Habana seed	do	Moderate	Do.
21	Portland Habana seed	do	Much	Do.
21	Poquonock, Conn., Habana seed.	Moderate	do	Passed through the natural sweat.

[a] One sample of 1893 crop, grown at Canton, Conn., showed no trace of oxidase or peroxidase.

Tobacco, cured and sweated—Continued.

MISCELLANEOUS SAMPLES.

Date.	Sample.	Oxidase.	Peroxidase.	Remarks.
1899.				
Mar. 4	Maryland tobacco, Jewell	None		1898 crop.
4	Virginia	do		Fine cured; 1896 crop.
Sept. 25	Wisconsin	do		1897 crop.
25	Lititz, Pa., broadleaf	do		1893 crop.
25	Lititz, Pa., Habana seed	do	Trace	1897 crop.
25	Hatfield, Mass., broad-leaf.	Moderate	Much	1898 crop, single-leaf cured.
Nov. 1	Ohio Zimmer Spanish	None	None	Stalk cured, crop of 1898, from Ohio.
	Ohio Little Dutch	do	Much	From Ohio.
Aug. 18	Hatfield, Mass., Habana seed long wrappers.	Much	do	Single-leaf cured and sweated in cases at 100° F. 1898.
18	Hatfield, Mass., suckers.	Moderate	do	Do.
18	Hatfield, Mass., top of suckers.	do	Moderate	Do.
18	Hatfield, Mass., ground leaves.	Little	do	Do.
Dec. —	Remedios, Cuba	None	Much	Crop of 1899.
	Pardido, Cuba	do	Slight trace	Do.
	Haiti	Trace	Much	Do.
	Puerto Rico	None	Moderate	Poor grade, 1899.
	Puerto Rico	do	do	Best grade.

We learn from these tables that the flue-curing process is unfavorable for the preservation of the oxidizing enzyms, and that sweated tobacco has frequently lost its entire content of oxidase, while the peroxidase is more resistant under the conditions of the sweating process. From the absence of oxidase in fermented leaves no conclusion can, of course, be drawn as to its amount before the sweating was begun. The more intensely the sweating process is carried on, the more of these oxydizing enzyms will be destroyed.

TEST FOR CATALASE IN VARIOUS TOBACCOS.

With regard to catalase, the third oxidizing enzym of tobacco mentioned above (page 22), some experiments were made on various samples of cured and sweated tobacco to determine the amount of oxygen developed by it from hydrogen peroxide in from fifteen to forty minutes. From the energy of this action inference may be drawn as to the relatively larger or smaller quantity of the enzym in different samples. Tobaccos that had been fire-cured, as the plug tobaccos, contain in most cases neither oxidase, peroxidase, nor catalase. Such samples examined were bright yellow Virginia, black African, and English olive-green leaf. A sample of Burley tobacco showed, however, slight traces of peroxidase and catalase. Since the temperature in this curing method often rises as high as 82° C. (180° F.) these observations do not surprise us. Also a flue-cured sample of yellow tobacco from North Carolina did not show traces of the three enzyms. Such tobaccos are not intended for cigars and are not submitted to the sweating process, hence the absence of the oxidizing enzyms is here not of any conse-

quence. But there are also conditions in the usual treatment of cigar tobacco which may injure the catalase. Thus no trace of it was found in one sample of sweated tobacco from Connecticut of 1897. In most cases, however, catalase is retained in the sweated cigar tobacco for a much longer time than either oxidase or peroxidase.

The comparative tests for α and β catalase were carried out in the following way: The air-dried samples were very finely powdered after removal of the midrib. After remaining twenty-four hours in an exsiccator 2 grams were extracted for five hours with 40 c. c. of water at the ordinary temperature with frequent shaking, and then filtered through filter paper. Twenty cubic centimeters of the filtrate were mixed with 5 c. c. of neutralized commercial hydrogen peroxide. The development of oxygen by the soluble or β-catalase commences a few seconds after mixing. Then the extracted tobacco powder was, after washing, suspended in 30 c. c. of water and 10 c. c. of hydrogen peroxide added. The oxygen here developed was due to the action of the insoluble or α catalase. The proportion of the developed oxygen gradually decreased in all cases after a short time, since the hydrogen peroxide in the concentration applied oxidized and killed the enzym rather soon. The reaction was promoted by moderately shaking the flask.

In those cases in which after a rapid development of oxygen gas an early stop was noticed a second dose of hydrogen peroxide was added, which was repeated as often as found necessary until the reaction had been carried on for a given time.

It will be noted from the method of testing just described that the data relating to β-catalase are obtained from 1 gram of tobacco; those relating to α-catalase from 2 grams.

Thus far no data are known that would enable us to calculate the absolute weight of catalase from a certain volume of oxygen developed in a given time by the decomposition of hydrogen peroxide. But quite generally we might make the following distinction as to relative quantities. The amount of α-catalase is small when under the above-described conditions less than 50 c. c. oxygen are developed in fifteen minutes by 2 grams of tobacco; it is moderate when between 50 and 200 c. c. are developed, and high when the volume rises above 200 c. c.

As to β-catalase the amount may be called small when less than 20 c. c. of oxygen are developed in fifteen minutes by 1 gram of tobacco; moderate, at 20 to 100 c. c., and high, when the volume rises above 100.

Sample.	Oxygen developed. Time of development.	By α-catalase.	By β-catalase.	Oxidase.	Peroxidase.	Remarks.
	Minutes.	*c. c.*	*c. c.*			
Connecticut broad-leaf.	5	22	1.0			
	10	34	1.8	Moderate	Much	Cured, 1899, but not sweated.
	15	42	2.0			
	30	66	2.0			
Florida, 1897	5	32	13.0		Some	Sweated in bulk.
	10	45	19.4	None		
	15	76	26.5			
	20	84	29.0			
	40		36.8			
Maryland smoker, 1898.	5	12	8.2			Light-colored, thin leaf, sweated slightly in bulk.
	10	22	11.8			
	15	28	13.2	None	None	
	30	36				
Ohio Zimmer Spanish	5	108	17.1			Crop of 1897, sweated in bulk.
	10	174	32.0	None	Trace	
	15		40.5			
	20		45.2			
Wisconsin, crop of 1897, "Gummy" leaves.	5	28	1.0	None	None	Natural sweat.
	10	40	1.7			
	15	46	1.9			
	20	49				
Pennsylvania	5	32	4.2			Passed through the "natural" sweat, 1898 crop.
	10	50		None	Moderate	
	15	67				
	20	76	16.3			
	30	86				
	40	89				
Remedios, Cuba	5	27	3.2			Sweated, 1899.
	10	44	6.1	None	Much	
	15	60	7.5			
	20	71	8.0			
Pardido district, Cuba	5	14	8.2			Sweated, 1898.
	10	20	11.0	None	Trace	
	15	24	14.0			
	20	27	15.1			
	40	36				
Puerto Rico	5	16	3.5			Sweated, 1899.
	10	20	4.4			
	15	25	5.1	None	Little	

It was thought that it would also be of interest to test cigars of commerce for oxidizing enzyms. Of the samples procured, which were probably of very different ages, not one contained oxidase or peroxidase, but catalase was present in all, although the amount differed considerably to judge from the energy with which hydrogen peroxide was decomposed. As to cigarette tobacco, five different brands of cigarettes were examined, viz, Old Dominion, Sweet Caporal, Gold Leaf, Chesterfield, and Egyptian Prettiest, but only in the last named was any catalase found.

Oxygen developed in fifteen minutes.

Cigar samples.	Price.	By α-catalase.	By β-catalase.
		c. c.	*c. c.*
Arena	3 for 5 cents	91	5.5
Haranetts	2 for 5 cents	520	41.0
Marquis I	5 cents	71	13.2
Lucke Rolled		41	18.0
Union Glory	5 cents	85	8.0
La Valiar	10 cents	26	2.0
Herbert Spencer	do	273	29.5
General Arthur	do	304	13.3
No name	2 cents a piece	61	8.5
Do	5 cents a piece	102	17.5
Do	do	108	8.2
Do	do	32	3.8
Do		241	55.0
Egyptian cigarettes		36	2.0

It will be noticed from this table that there is no direct relation between the commercial value of a tobacco sample and its catalase content. On the one hand, however, it may be said that a comparatively high content of soluble or β-catalase would be indicative of this tobacco having been subjected to a sweating at a higher temperature, since the ammonia developed renders some catalase soluble. Further, since a thorough sweat is essential for the development of aroma, a high content of soluble or β-catalase would indicate an improved aroma, other things being equal. On the other hand, it might be inferred that a sample containing very little soluble, but comparatively much insoluble catalase (see No. 11 of the above table), has passed only through the natural sweat and could be improved by a subjection to sweating in bulk after petuning with a very diluted solution of ammonium carbonate.

In order to reach a reliable estimate of the extent of the transformation of the insoluble into the soluble catalase by the sweat only leaves of equal age and very similar to each other should serve for comparison. A cured leaf can not be compared with a sweated leaf of the same crop when the former happens to be a lower or sand leaf and the latter an upper leaf. Neither can thin, strawy leaves be compared with gummy leaves, since the differences between these are very great in regard to their enzym content. Thus, a not sweated, very thin, probably a sand leaf, yielded in fifteen minutes by the above test 7.7 c. c. oxygen for the soluble enzym and 69 c. c. for the insoluble, while a sweated, gummy leaf of the same crop yielded 147 c. c. and 360 c. c. oxygen, respectively. There can be no doubt, however, that the above tests, judiciously carried out, may prove of practical value in certain cases

In order to obtain comparable results, and to eliminate the factor of individual differences, upper leaves which can be distinguished by their heavier body were picked out of a lot of cured leaves and of a lot of leaves sweated in bulk, of the same crop.[1] After moistening them a little they were left over night until they became pliable, whereupon they were spread out and the adhering sand carefully brushed off. The central portions of 12 leaves were then deprived of the midrib, and after drying at 40° C. (104° F.)[2] finely pulverized. Two grams each of this powder were weighed out, and the tests carried out as above mentioned. The result was as follows:

Oxygen developed in thirty minutes.

	By α-catalase.	By β-catalase.
	c. c.	c. c.
Cured but not sweated, filler leaves	158	16.5
Cured and sweated, filler leaves	634	236.0
Proportions of the volumes of oxygen	1:4	1:14.3

[1] This tobacco, raised in 1899, came from the Experimental Farm of the Conn. Expt. Sta. in Poquonock, Conn. The curing was there supported by a careful application of artificial heat, and supervised by Dr. E. H. Jenkins.

[2] Tobacco kept at that temperature in a drying box does not become completely dry—still retains 4 to 5 per cent moisture.

We notice from these figures not only an enormous increase of β-catalase, but also a considerable increase of α-catalase. It had been observed twice before by the writer that the α-catalase also was increased in the sweated sample as compared with the cured sample. He ascribed this circumstance to accidental differences in the leaf character. But this supposition has to be abandoned in view of the above figures obtained from average samples. The only explanation the writer can offer that seems probable is, that there exists in the case of catalase, as with many other enzyms, a zymogen in the leaves, which, under the conditions brought about in the sweating process, is converted into the α-catalase enzym itself.[1]

The relative intensity of the fermentation, or sweating, has also a decided influence upon the amount of β-catalase. Thus, upper leaves moderately sweated for wrapper purposes contain less than upper leaves heavily sweated for filler purposes. The amount of oxygen developed in thirty minutes by β-catalase was observed with the sample of the former to be 186 c. c., of the latter, however, 236 c. c. (both of the same crop). The difference in the amount of oxygen developed in thirty minutes in both cases by α-catalase was but small, 619 and 634 c. c. oxygen, respectively.

In order to decide whether the petuning liquid[2] which was applied for the filler leaves, but not for the wrapper leaves, had contributed to the increase of the amount of catalase, 20 c. c. of that liquid were, after neutralization, mixed with 20 c. c. of water and 5 c. c. commercial hydrogen peroxide. The total amount of oxygen developed in thirty minutes was but 26 c. c. Since the amount of the petuning liquid applied was only 0.66 per cent of the weight of the tobacco, not more than 0.02 c. c. of oxygen gas would have been developed in thirty minutes by the amount of petune contained in 2 grams of tobacco applied for the test on catalase, an amount so small that it can be neglected.

DEVELOPMENT OF THE "GRAIN" OF THE TOBACCO LEAF.

The "grain" means to the tobacco manufacturer small points plainly visible on the extended leaves after the curing or after the sweating process. These points, often situated at the base of the hairs, appear under the magnifying glass as small globules of yellowish color, showing sometimes a radiated structure. Boiling with water or with dilute acetic acid does not remove them, but treatment with dilute hydrochloric acid does so at once. This makes it very probable that the chief mass of these globules consisted of calcium oxalate, a view confirmed by the microscopical observation of gypsum needles forming under the

[1] The writer holds as probable that while α-catalase may be generated from a zymogen, β-catalase is produced from α-catalase only, and not from a separate zymogen.

[2] This liquid was prepared from licorice and various condiments, with addition of some rum, according to the prescription given by Marcus L. Floyd in Report No. 62, U. S. Department of Agriculture, p. 19, Cultivation of Cigar Leaf Tobacco in Florida.

influence of concentrated sulphuric acid upon the "grain." Although there is some calcium oxalate present in the living leaf, the oxalic acid of those globules is produced by post-mortem oxidation, since they do not exist in the living leaf, the natural inference being that it is the oxidizing enzyms that produce them by inducing oxidation of various compounds, such as malic or citric acid, tannin, etc. The more oxidizable material, and the more oxidation is going on in the tobacco leaf, the more will the so-called grain develop in the curing and sweating process; hence it will in many cases, by no means in all, confirm the idea of some tobacco manufacturers that a well-developed grain is a good sign for the quality of the tobacco.

The following observations by the writer may be mentioned: A fresh tobacco leaf was divided into two portions. One portion was hung up in a covered beaker containing some water, the other was first heated to 60° C. (140° F.) in a closed vessel before being thus treated. By the sudden killing of the cells by heat the cell sap left them at once and spread uniformly over the surface of the leaf, while in the former case the gradual drying and the later death diminish the migration of soluble matter to the surface. After eighteen days the "grain," in the form of numerous globules of calcium oxalate, was formed in the normally curing leaf, but not a trace of it was seen in the leaf killed immediately after collecting it. This shows that these globular masses were formed in the curing process. In the fresh leaves deposits of calcium oxalate also occur as mentioned, forming crystalline sandy deposits, especially in mesophyll cells. Generally these seem too small to account for the appearance of the "grain" in cured and sweated leaves.

The nature of the "grain" was also investigated by Dr. W. C. Sturgis, who arrived at the same conclusion as the writer and at about the same time. That author had the kindness to communicate the following observations:

> The crystalline deposits are insoluble in water, but are completely and readily soluble in dilute hydrochloric acid. On heating, these deposits swell to three or four times their original volume. Examination under the microscope of these heated masses in water, with the addition of hydrochloric acid, show that they are at once dissolved with copious evolution of gas. These observations, coupled with what we know of the occurrence of calcium oxalate in leaf tissues, lead me to conclude that the grain of certain grades of tobacco is caused by the deposition in limited areas of crystalline aggregations of this salt.

REMARKS ON THE DEVELOPMENT OF THE BROWN COLOR.

The slow starvation process of the tobacco leaf in the curing barn is connected with the yellowing of the leaves, followed by the characteristic brown. The yellow color is chiefly due to the etiolating of the chlorophyll granules because of the absence of bright daylight, and sets in while the cells are still alive, while the brown color sets in after their death. The changes of the green to yellow and of the yellow to brown start and proceed generally in the same order, commencing at the margin and about midway between the lateral veins. Along

the thicker part of the veins the tissue remains green longest. Gradually a stage is reached in which only the midrib and basal parts of the lateral ribs still have their normal color, being fringed by but narrow strips of yellow mesophyll, the chief mass of the leaf having turned brown.[1] Thus, the layman is inclined to infer that the substance which turns yellow is also the same that turns brown later on. This, however, is not correct. The yellow color is due to a chemical change of the chlorophyll green, while the brown color is due to the oxidation of several different compounds contained in the cell sap. The brown color shows also in the veins of the leaf, but not the yellow, since there is too little chlorophyll in the veins. It sometimes happens, however, that leaves in the barn die quickly by drying up instead of slowly by starvation, thus not allowing sufficient time for development of the yellow color, and in this case the brown color develops directly upon the still green leaf. Such leaves show a distinctly green coloration when held between the eye and the bright daylight, and on treatment with strong alcohol they yield a green solution of chlorophyll, showing that the green is not destroyed, but merely concealed by the brown. The chlorophyll, therefore, is not the source of the brown coloration. Furthermore, when a fresh leaf is dried at a moderate temperature in an air bath it will no longer turn yellow when exposed for a considerable time to a moist atmosphere, showing that the change from green to yellow in the curing barn is still a process of life, although a pathologic one.

As to the brown color, it can easily be shown that it is produced by the action of oxidase and not by the action of peroxidase, since after "killing" the oxidase the brown color fails to develop. Freshly expressed juice of the midrib was heated for four minutes to 75° C. (167° F.) and left with a little chloroform in a flask plugged with cotton. After ten days this liquid was still colorless, although containing peroxidase, while the control liquid became light brown within one day.[2] The juice of the lamina turns dark brown much sooner.

WHY DOES THE OXIDASE NOT PRODUCE THE BROWN COLOR WHILE THE LEAF IS ALIVE?

The oxidizing enzyms are evidently contained in the plasmatic living part of the cell, and not in the cell sap which fills the vacuoles. On the other hand, the matters easily oxidized by them and representing products of metabolism or by-products of certain synthetical operations are mostly contained in the cell sap. These matters, often of a chromo-

[1] The brown color darkens still more during the sweating process. When the expressed juice of green tobacco leaves, after filtering, is exposed to air it gradually forms an insoluble deposit, the greater part of which consists of a phlobaphen-like, dark-brown substance, and the smaller part of a colorless flocculent compound. The former is easily soluble in dilute ammonia; the latter is not.

[2] It may be mentioned here that, according to A. Mayer, a dark-colored tobacco is obtained by a rich nitrogenous manuring, and that, according to Kosutany, barnyard manure with ammonium salts yields a product of a reddish brown tint, while nitrate manuring yields a more greenish-brown one.

genic character, are, of course, produced in the plasmatic parts, but secreted rapidly into the cell sap. When the cells die the soluble substances locally separated in the cytoplasm and the cell sap intimately mix, since the coagulating protoplasm, becoming easily permeable, can no longer retain any soluble matters—as, for example, oxidase. Thus after death the direct action of the oxidase on the oxidizable matter of the cell sap sets in with a production of colored bodies, as is the case in the tobacco leaves. This action can also be noticed very well in the juice pressed out from the fresh leaves, since this juice, containing cell sap as well as soluble matters previously contained in the protoplasm, turns brown rapidly on coming into contact with air. The darkening of the juices of potatoes, beets, and other plants depends upon the same principle.

CHROMOGENS OF TOBACCO.

The nature of the chromogenic compounds has not yet been fully revealed. It was pointed out in Report No. 59, p. 12, that several different compounds have to be assumed as contributing to the color in the tobacco leaf, and that tannin as well as nicotine contribute only a part of it. It is true that the darker tobaccos are generally considered as being the stronger—that is, contain the most nicotine—but, on the other hand, it has to be kept in mind that the veins, which contain less nicotine than the lamina, are generally much darker colored, a fact hardly to be explained merely by the thicker layer of cells. The fact, however, that the juice of the lamina turns dark more quickly and intensely than the juice of the rib makes it probable that the chromogen of the ribs is not easily soluble and differs from that of the lamina. In the lamina it is the mesophyll and not the epidermis that contains the chief quantity of the chromogen.

The main chromogens of the leaves are insoluble in alcohol, as is the brown product itself. A piece of young, green tobacco leaf was left in alcohol for one day, the chlorophyll being extracted and the leaf becoming almost colorless. Upon moistening with water it turned brown within two days, the color being darkest in the ribs and veins. The main chromogen, therefore, had not been removed by the alcohol treatment.

There is but very little chromogen in the pith, since it becomes only slightly brown after several days' exposure to the air; equally little is contained in the vascular bundles of the stalks, except in the youngest part. The study of the nature of the chromogens encounters considerable difficulties.[1]

[1] After this was written, an article of Behrens appeared in the Landw. Vers. Stat., vol. 52, in which he discusses the production of the color. He thinks that the brown substance is formed from a chromogen which is split off from a glucosid, and that this glucosid is formed during the first or starvation period of the leaves in the barn. This opinion can hardly be accepted when we observe the rapidity with which the juice of the fresh leaves turns brown upon exposure to the air, showing that the chromogen, or rather the "soluble" chromogen, is already present in the normal leaf.

SUNBURNED TOBACCO LEAVES.

When the tobacco plants are harvested it often occurs that the cut plants are left for several hours in the field, exposed to a scorching sun, and many of the leaves are killed either in part or in isolated spots. These prematurely killed portions remain green and never change color in the curing barn. There are, indeed, not infrequently found among the cured leaves of commerce some with green spots on them, due to this circumstance. The microscope reveals the fact that the fine veins of such spots are only of a faint brown color, compared with the well-cured portions.

It appears to be of some interest to decide whether it is only the effect of the intense light which causes such a change in the properties of the leaf, or whether a partial drying up in the sun forms one of the conditions. Possibly the light may kill the enzyms as soon as the cells themselves are killed by the heat. The gathered leaves warm up with the sun's rays considerably more than the leaves of plants standing in the field, where the transpiration current provides moisture which lowers the temperature by continuous evaporation.

A piece of ripe leaf was heated in a closed test tube in a water bath for five minutes to from 60 to 61° C., which caused the loss of the natural stiffness (turgor), the change being caused by the loss of the osmotic properties of the plasma sack when the leaf dies. Another piece of the same leaf was heated to 60° C. for five minutes, and then for five minutes longer to a temperature of from 70 to 71° C. Both of these pieces were hung up in a covered beaker containing some water, and compared with another piece of the same leaf not so treated. After eighteen days the pieces were moistened and spread on a glass plate, when it was easily recognized that the color of the piece heated to a temperature of from 60 to 61° C. was almost the same as that of the control piece, while the color of that heated finally to a temperature of from 70 to 71° C. had a far different look, only the larger veins having become brown,[1] while the lamina was of a weak yellowish green. This shows that the production of color is due to the action of the oxidase (not yet killed at 60° C.), and not to the peroxidase (not yet killed at 70° C.), since a special test proved that the piece heated for five minutes to a temperature of from 70 to 71° C. contained considerable peroxidase, but no longer any oxidase. Still the analogy to the sunburned leaves was not fully established by this test, since the sunburned leaves retain their full natural green, while with the samples mentioned the original green was somewhat changed. Tests in which the pieces of the leaf were not, however, treated in closed test tubes, but were left to dry openly in an air-bath at 58° C., gave a different result. In these the green was preserved almost in its natural condition, and

[1] This browning was probably developed between 40 and 66°, after the death of the cell and before the death point of the oxidase was reached.

the subsequent exposure to the moist air led only to a coloration of the veins. The lamina remained green. The simultaneous effect of heat and of drying up must unite, therefore, to produce the phenomena observed in "sunburned" leaves.

"WHITE VEINS."

The phenomenon of "white veins" is observed in the curing barn after a long spell of dry and warm weather. The veins then lose the capacity of turning brown on the surface, and preserve a whitish or rather colorless appearance after the curing process is over. On holding such a leaf between the eye and the light, a sufficiently dark-brown coloration of these veins is plainly seen, hence it is only the surface which is devoid of coloring matter. There is hardly any other explanation than that by a too rapid drying the epidermis cells of the veins died too quickly and this premature death caused the entrance of air into and perhaps also below them,[1] leading to the optical illusion that coloring matter is absent in the veins, although the interior cells (those of the vascular bundle) contain it.[2] The microscope reveals colorless and air-containing tissue around the brown sieve-tissue masses in the "white veins," while in the normally colored veins the tissue surrounding the sieve tissue is more or less yellowish brown. The presence of "white veins" decreases the value of the wrapper leaf, while it has no influence upon the value of the fillers. On the contrary, such fillers may often be very valuable. To prevent the "white veins" there seems no other way possible than to keep the barn closed in prolonged hot, dry weather and to occasionally sprinkle water through the barn.

"SALTPETER" ON TOBACCO.

A phenomenon resembling to some extent that of "white veins," but in reality very different from it, is the efflorescence of a white saline mass upon the midrib and lateral ribs of the curing tobacco leaf. The tobacco planters and manufacturers call it "saltpeter," but sometimes there are only traces of saltpeter (nitrates) found in these efflorescences. They contain principally a mixture of potassium, sodium, calcium, and nicotine salts. The writer has not chanced to observe an efflorescence consisting only of saltpeter, although the possibility of such an occurrence can not be denied. The phenomenon is probably caused by a long spell of dry weather in the first stages of the curing.

Finally, it may be mentioned that sometimes a white mycelium of some fungus makes its appearance on the veins of the curing leaf,

[1] Such a phenomenon is also frequently noticed in August on the leaves of the peach tree, as Dr. Galloway has kindly pointed out to the writer.

[2] Mr. Floyd reported to the writer that occasionally white veins are also noticeable in plants while growing in the fields, and that in such cases the leaves are usually of a very dark green.

since the veins retain more moisture than the lamina and thus favor fungous growth more than the latter. This phenomenon is, however, very easily distinguished from that of the genuine "white veins."

METHODS OF SWEATING.

There are three methods of sweating practiced in the United States, viz:

(1) The natural sweat in cases.
(2) The forced sweat in cases.
(3) The sweating in bulk.

The natural sweat is a slow process going on in cases. The low temperature in winter and spring in conjunction with the limited access of air is, however, an unfavorable condition. Besides, the absence of an energetic sweating process favors the growth of fungi upon the tobacco leaves when the tobacco has been packed too moist. The higher temperature used in the other two methods hastens the process of sweating and the development of aroma, and thus the tobacco can be put on the market a considerable time in advance of what could ordinarily have been done. The advantage of an early market is much desired by all packers.

The "forced sweat in cases" requires about the same length of time as the "sweating in bulk." A natural sweat for from six to ten months, followed by a sweating in bulk for from two to four weeks, is applied in Lancaster, Pa., for filler tobacco. Only when fear of must exists is new tobacco there at present subjected directly to the "forced sweat in cases," and this process is sometimes followed by a short "sweating in bulk" when the color for the fillers has not become dark enough.[1]

An important difference between the "sweating in bulk" and the "sweating in cases" is the greater access of air in the former method. The amount of oxygen for the "sweating in cases" is restricted to that contained in the air of the cases[2] and in the air which enters through the sides and at the corners. By this lessening of the access of air the processes of oxidation are retarded and a considerable rise of temperature by the sweating itself is prevented. Hence, this method is carried on in rooms at from 37.7° to 43.3° C. (100–110° F.) without fear of undue spontaneous further rise in temperature in the tobacco

[1] Dark fillers and light wrappers are at present in demand. A thorough sweat, although leading to a fine aroma, will also produce a dark color, hence the sweat has to be limited when wrappers of a light color are to be produced. This is one of the reasons that the wrappers are moistened with less water than the fillers before sweating. The tip of the leaf is better adapted for wrappers than the base or "heel," as the tobacco manufacturer calls it, on account of its greater flexibility—produced by differences in the vascular bundles near the tip which consist mainly of spiral vessels, while near the base there are also pitted vessels.

[2] This amount is small, as the tobacco leaves are packed in cases with the aid of a press. No pressure is applied for the fermentation in bulk, in order not to diminish the necessarily limited access of oxygen.

itself. The cases are piled up in these rooms heated often merely by an iron stove, which holds a vessel of water to produce a moist temperature so as to prevent the tobacco from drying out too much.

With the "sweating in bulk" the condition differs.[1] The rooms generally have a temperature averaging from 21–28° C. (70–85° F.), and the only covering for the tobacco consists of blankets, which admit air freely between the sweating "hands" of tobacco. The oxidation processes can therefore be carried on with much more energy, leading to a considerable rise in temperature above that of the room, a rise amounting daily to from 5 to 8° C. (9 to 14° F.). A great advantage of the fermentation in bulk is that these bulks are repeatedly turned over and rebuilt, which enables a minute examination. A careful workman is thus able to observe whether the process is going on normally and can frequently remedy troubles. The forced sweat in cases, however, does not have this advantage. As to the ammonia produced by the sweating, there can be no doubt that it is a normal product of the destruction of the nitrogenous compounds by the oxidizing enzyms, and not a product of putrefaction, as held by some authors. The writer showed in Report No. 59 that bacteria of putrefaction can not thrive upon tobacco leaves in the sweating condition. Every normally sweated tobacco contains some ammonium salts.[2] It depends upon the amount of ammonia thus formed whether a tobacco of commerce shows a faintly acid, a neutral, or a faintly alkaline reaction.

As to the question which especial compounds are attacked in the sweating process by the oxidizing enzyms in the leaves, it is probable that all soluble organic compounds present in the leaf are attacked, but with a different degree of intensity. Although certain compounds, such as nicotine, may be attacked with difficulty, a noticeable amount may nevertheless become oxidized in the course of time, since the sweat in the bulk or the forced sweat in cases lasts about six weeks. The oxidation need not lead directly to the production of carbonic acid with every compound, as there may be formed intermediate oxidation products, which undergo further oxidation but slowly. By allowing the temperature to rise to about 65° C., which is 5 degrees higher than the generally adopted maximum, the oxidation may even extend so far that the aroma first produced is again destroyed and that the extractive matters are diminished until a very large percentage of the tobacco consists of mere cellulose. Tobacco manufacturers call such an inferior product "papery." Nevertheless the temperature of the fermenting wrappers in Sumatra is sometimes

[1] Report No. 60, U. S. Department of Agriculture, Temperature Changes in the Fermenting Piles of Cigar Leaf Tobacco, by Milton Whitney and Thomas H. Means. This report contains a full description of the "sweating in bulk" as practiced in Florida.

[2] Thoms obtained 38 grains of ammonium sulphate from 15 kilograms sweated tobacco on distillation with steam; but only a part of the ammonia is obtained in this way. Various analyses give from 0.05 to 0.5 per cent ammonia in tobacco.

allowed to reach 65° C. (109° F.), as Van Bemmelen reports.[1] When this temperature is kept up for some time or is allowed to rise some degrees higher, the tobacco loses its power of heating up again when the heap is repacked. The oxidase and catalase are now killed. Such tobacco is called "cooked." It is knotty and curled and the fiber has lost much of its elasticity.[2]

NOTES ON THE BACTERIAL HYPOTHESIS OF SWEATING.

Although it was shown in Report No. 59 that Suchsland's bacterial hypothesis of the sweating of the tobacco is unfounded and that the true cause of the oxidation in the sweating process must be attributed to the presence of oxidizing enzyms in the tobacco leaf itself, nevertheless some persons still adhere to the bacterial hypothesis. But it is a simple matter for anyone to convince himself by direct microscopical examination of scrapings from moistened sweating wrapper leaves that the numerous bacteria which would be expected, by the hypothesis, are not there. Even if we assume that the supposed tobacco bacteria are characterized by extraordinary capacities of oxidation and fermentation, and that therefore a restricted number might account for a great deal of work, several millions at least should exist for every square inch. Further, it is evident that the conditions on the tobacco leaves are most unfavorable for bacterial growth. It was pointed out by the writer that the water content of a fermenting wrapper leaf is utterly insufficient to bring the nutritive compounds from the interior of the cells to the surface, the moisture being barely sufficient for the proper imbibition of membranes and cell contents. The easily soluble matters, such as oxidizing enzyms, will no doubt dissolve, but this solution will be retained in the chief mass of the cell contents.

Let us assume that all the water of a sweating leaf would be available for the cell contents—none being retained by imbibition of the cell membranes—and, further, that one-half of the cell contents is easily soluble in water, although in reality two-thirds are easily soluble in their own weight in water. A fermenting wrapper leaf with a water content of 20 per cent[3] would then contain a solution of organic matter of a strength of 50 per cent, since ripe wrapper leaves of good quality and capable of fermentation contain in the dry substance an average of 40 per cent of matter soluble in water.[4] In such a solution of 50 per cent of organic substances bacteria can not multiply. Even mold

[1] Landw. Vers. Stat. vol. 37, p. 383.

[2] This is the experience of tobacco manufacturers of Florida, and has been mentioned to the writer by Mr. M. L. Floyd.

[3] The tenacity and cohesion of wrapper leaves are generally seriously injured as soon as the water content is increased above 27 per cent while the sweating is going on.

[4] Of course the percentage of soluble matters varies considerably in different grades of tobacco.

fungi find it rather difficult to live under those conditions.[1] In reality the conditions are still much less favorable for bacteria than we have assumed in this calculation. The high temperature is also an obstacle to most bacteria. Fermenting wrapper leaves sometimes reach a temperature of 60° C. (140° F.), and still ferment again when the heap is repacked. It would be a very easy matter to isolate the active bacteria, if they should belong to the few thermophylic kinds that can be active in such a high temperature. But nine years have passed since the promulgation of the bacterial theory of tobacco fermentation, and thus far there is nowhere to be found a scientific description of the supposed tobacco bacterium.

The following experiment shows that bacteria from the very surface of the tobacco leaves can not thrive in a concentrated tobacco extract. Such an extract containing 30.2 per cent of solid matter was sterilized and a small piece (about 1 cm. square) of a freshly cured tobacco leaf[2] introduced, after which the flask was plugged with cotton. After 10 days neither a scum nor a turbidity indicating the presence of bacteria could be noticed, but some clot-like masses were observed. These masses proved to consist of a mycelium of a fungus, while even with the highest magnifying power no microbes could be observed. However, a dilute solution, prepared by diluting the former with ten times its volume of water, formed a bacterial scum within two days upon exposure to the air.

In a second trial, with a concentrated solution of 25 per cent of tobacco extract (contained in a test tube) exposed to the air for ten days to admit various kinds of microbes, there was neither a scum nor a bacterial turbidity produced. On microscopical examination, however, some few bacteria could be noticed. Now, if solutions of such concentrations are so very unfavorable for bacterial growth, how much more must this be the case for the much higher concentration to be found in the cells of the fermenting wrapper leaves?

Further experiments proved that even at a water content of 35 and 40 per cent present in fermenting fillers[3] bacteria can not flourish upon the leaf surface at the temperature of the fermenting piles. In freshly cured heavy tobacco the water was determined and enough water added so that in two samples the percentage reached 35 and 40 per cent, respectively. These leaves were rolled up and placed in flasks, which were sealed with paraffin and kept for five days at a temperature of from 53° to 55° C., there being an abundance of air in the flasks. For

[1] According to Splendore (Revista Tecnica, Roma, 1899), Oospora Nicotianæ can not develop upon tobacco that has less than 26 per cent of water, and, according to Behrens (Landw. Vers. Stat., Aug., 1899), Botrytis requires at least 30 per cent of water in cured tobacco to be able to grow on it.

[2] This tobacco contained catalase, oxidase, and peroxidase and was subjected to "sweating" or "fermentation in bulk." It sweated normally.

[3] Hands of filler tobacco are dipped with their base deeper into the water than hands of wrapper tobacco, thus securing a higher water content.

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a short time the temperature reached 59°, but since even 60° is frequently observed in the fermenting tobacco piles this temperature should not be expected to kill the supposed tobacco bacteria. The microscopical examination of the leaves after five days proved the absence of a bacterial coating. Only here and there a microbe was found, but upon staining and counting in everything which had any resemblance to a spore or bacillus there were not more than 600 microbes to the square inch. The examination was made not only of scrapings of the moistened surface, but of the triturated parts of the leaf itself.

Recently a treatise by H. Vernhout has appeared in which a microbe closely related to Bacillus subtilis is described from fermenting tobacco leaves in Java.[1] The author ascribes to this the phenomena of tobacco fermentation. The proof, however, that this microbe can produce fermentation and can multiply on tobacco leaves with only 25 per cent water has not been adduced. His further remark that a sample of cured tobacco did not contain any oxidase or peroxidase does not require any further comment, since these enzyms may disappear as above mentioned under unfavorable conditions, while catalase, the third oxidizing enzym, still may persist.

SWEATING MUSTY TOBACCO.

The complaints about "musty tobacco," "white mold," and "black rot" in tobacco packed in cases are quite frequent. Moist weather toward the end of the curing, and especially while stripping and packing are going on, favors these injuries. Apparently quite healthy tobacco will often, after having passed through the natural or cold sweat, have a moldy odor[2] or a cover of a white film of fungus mycelium, or even patches where the leaves are transformed into a powder by the so-called black rot.[3] Dark heavy tobacco is said to be most damaged by "white mold." Because of this damage the value of the tobacco is decreased to about one-sixth of the original. A tobacco manufacturer assured the writer that out of 1,600 cases of tobacco of a particular crop he found 1,300 cases more or less damaged in this way, and he estimated the damage annually caused in this country at about $1,000,000. Repacking after removing the worst portions affords but a poor help and but for a short time. In the case of black rot further serious damage can be prevented more easily by repacking, since this fungus does not continue to spread after cold weather sets in in autumn. The chief remedy

[1] Onderzoek over Bakterien bij de Fermentatie der Tabak, Batavia, 1899.

[2] The moldy odor is caused by the growth of the common mold fungus, *Penicillium glaucum*.

[3] In a case of black rot examined by Mr. E. A. Bessey, in which the cohesion of the parts of the leaf was destroyed and patches of it transformed into a pulverulent mass, the fungus *Sterigmatocystis nigra* (*Aspergillus niger*) was found.

applied at present is a "forced sweat," in which the musty odor disappears and the mycelia of the fungi are killed; but when this process is not thoroughly carried on the spores may be uninjured, and thus it happens that the musty odor may come back again when these spores develop.

This forced sweat is carried on in the presence of much water—45 or 50 per cent—and is therefore suitable only for fillers, since under such conditions the wrapper leaf would deteriorate considerably. The writer has observed that with a room temperature of 26.6° C. (80° F.) and a water content in the tobacco of 47.6 per cent the temperature of a large box filled with such moistened musty tobacco was markedly increased within four hours, and in two days reached a temperature of 40.5° C. (105° F.). From three to four days are allowed for this sweat in summer, and from one to two weeks in winter.[1] Tobacco that has passed through a "forced sweat" will not again heat up sufficiently, while after a cold or natural sweat it will heat up readily.

Some suggestions might be made as to how to prevent, as far as possible, the deterioration of cured tobacco by fungi. Whenever the stripping cellars are underground or immediately under the curing barn, the moisture of the air in the cellar often increases to such an extent that the stripped tobacco absorbs too much moisture before it is packed. When the water content of tobacco rises above 30 per cent there is great danger of the development of fungus spores which may be present on the tobacco leaves. Besides, in such damp localities various fungi develop on the floor and walls where organic impurities have gained lodgment, and hence the opportunities for the infection of the tobacco in the stripping process are much enhanced. Some farmers have recognized this dangerous source of infection and fumigate the stripping cellars with burning sulphur before commencing the work. The mycelia of fungi can easily be destroyed by this process, but the more resistant spores may escape destruction. Another means of cleaning the cellars is to whitewash them several times with freshly slaked lime and dry them out well with artificial heat before the stripping commences. It would be still better to have the stripping localities above ground and have them kept warm while the stripping is going on.

An essential step of progress would be made by giving up altogether the natural or cold sweat and by replacing it with the "sweating in bulk," to be carried out soon after the curing process is finished. The fungus spores, the germination of which is hastened by heat, are gradually killed in that state when the temperature rises above 50° C., and thus the fungus development injurious to the tobacco is easily avoided.

A few words may be said in this connection about measures for the prevention of stem rot. "Stem rot," a disease sometimes developing and spreading in the curing barn, has been investigated by Dr. W. C.

[1] Such resweated tobacco is generally not packed again, but serves directly for the manufacture of cigars.

Sturgis, who named the fungus *Botrytis longibranchiata*.[1] He recommends that all the diseased stems and leaves be collected and burned at once, before the fungus is further developed and before its spores can be scattered about by any current of air. He further suggests sprinkling the floor of the barn with a mixture of equal parts of air-slaked lime and sulphur, and the fumigation of the tightly closed barn with burning sulphur a fortnight before the tobacco is harvested, and again after the removal of the cured tobacco from the barn. It may be added here that washing the floor with thick milk of lime which has been recently slaked in the usual way has also been found beneficial.

AROMA OF THE TOBACCO.

The odor developed in smoking a cigar may be partly due to the mere volatilization of products of the sweat and partly to the destruction of certain compounds. The heat of the glowing surface reaching the neighboring sections which are not in full contact with air causes there volatilization and various decompositions by dry distillation. Products of pleasant and of unpleasant odor are components of the smoke, and it is the chief aim of the progressive dealers in the tobacco trade to reduce the amount of the latter components to a minimum. In the smoke of tobacco have been found besides carbonic acid and water, nicotine, ammonia, carbonic oxid, occasionally nicotianine and traces of hydrogen cyanide, and hydrogen sulphide. Recently pyridine, trimethylamine, and butyric acid have been found in it by Thoms.[2] The pyridine is produced by the decomposition of nicotine, while the hydrogen cyanide, hydrogen sulphide, and butyric acid are probably derived from protein compounds.

The soil, climate, and weather on the one hand and careful treatment in the curing and sweating of the tobacco on the other have great influence in the production of a cigar leaf having the proper aroma in smoking. This flavor must be distinguished from the odor which the sweated tobacco leaves show directly without being heated or smoked. The writer proposes to designate the former alone as aroma, while the latter will be called simply odor. The use of this distinction is made in the following lines.

The odor of the sweated tobacco leaves doubtless stands in a certain relation to the aroma generated in smoking, generally a pleasant odor justifying the inference of a fine aroma; but this is by no means always so, and cases occur where a sweated tobacco of pleasant odor produces a disagreeable odor on being smoked. The aromatic substances may here escape perception because of the presence of other and undesirable compounds. The substances which impart the odor are easily soluble in water, since tobacco extracted with water and dried again has no longer

[1] Conn. Agr. Expt. Station, Annual Report, 1891, p. 185.
[2] Chem. Zeitg., 1899, No. 80.

its characteristic odor. "Nicotine free" cigars made of such tobacco are also devoid of any trace of aroma. Treatment with much alcohol also removes the odor more or less, and this alcoholic extract on evaporation at the ordinary temperature leaves a residue recalling the odor of the tobacco. This residue upon treatment with ether can be separated into a soluble and an insoluble part, but neither of these has any odor, showing that the substances which caused the odor are easily volatilized or chemically changed. Indeed, they are easily changeable, as can be observed when sweated tobacco is distilled with water. Five hundred and fifty grams of Florida tobacco of a superior odor were mixed with eight times its weight of water and nearly 300 c. c. were distilled off. On the surface of the slightly turbid distillate, which had a weak but rather disagreeable odor, resembling somewhat that of rancid oils, minute oil drops were seen. Not only was the distillate devoid of any specific odor, but also the contents left in the flask had lost the original odor. The odor is also easily removed by dry heat. Two hours exposure to air at a temperature of 100° C. (212° F.) suffices to deprive tobacco of most agreeable odor of this desirable quality.

Tobacco leaves, even from the best tobacco regions, are by no means distinguished by peculiar flavor in their fresh or cured state.[1] The curing exerts a beneficial effect upon the quality of the aroma only in so far as a part of the protein is destroyed by it. Cured tobacco, even from the best sources, has a mere straw odor. The fine odor and genuine aroma are generated by the sweating process. The better regulated the sweating process, the finer the aroma, other things being equal. Whenever the sweat is not proceeding well—ascribed sometimes to a high fat content, or perhaps caused by imperfect curing, or by injuries to the oxidizing enzyms in the curing barn—the product will have a poor aroma. These circumstances make it clear that the original resin in the leaves can not be the cause of the aroma, as some authors have surmised. Indeed, the resinous matter from fresh or cured leaves does not show any particular flavor when heated; neither has the ethereal oil contained in the hairs of the fresh leaves a beneficial effect on the quality of the tobacco.

It is well known that it is especially the so-called gummy leaves that sweat best and give the finest aroma. Such leaves are found among the upper and not among the lower or sand leaves, and are very rich in extractive matters. When such leaves are shrinking in the process of drying in the curing process, these soluble matters may sometimes be forced to the surface, to some extent, in the form of a concentrated solu-

[1] While the juice of fresh tobacco leaves assumes, after a short time, the odor of cucumbers, fresh leaves dried at 50° C., and afterwards moderately warmed with water, gradually develop the agreeable odor of dried malt; an interesting fact, since the germinating barley on the malting floor also at first develops the odor of cucumbers.

tion, hence such leaves feel sticky or gummy to the touch. By a thorough sweat this "gum is taken out," as the manufacturer says; in other words these extractive matters are more or less oxidized.[1] It is therefore of interest to determine the amount of soluble matter left after sweating. This amount varies considerably, from 30 to 54 per cent. The insoluble matter consists mainly of cellulose, lignin, protein, coloring matter, fat, resin, and ash. With some samples the following results were obtained:

	1.	2.	3.	4.
Soluble	37.1	33.8	37.5	44.3
Insoluble	62.9	66.2	62.5	55.7

Sample No. 2 showed saline efflorescences (so-called "saltpeter") on the veins. Sample No. 4 consisted of co-called "gummy leaves." The ash varied from 19.4 to 22.1 per cent in those samples.

It was formerly believed that the aroma was chiefly due to the so-called tobacco camphor or nicotianine—a crystalline volatile product which was obtained by distillation of sweated tobacco with water. Hermbstadt tried, as early as 1821, to isolate this aromatic principle. On distilling various samples with six times the weight of water he obtained a distillate yielding a precipitate with acetate of lead, from which a crystallized compound of a strong tobacco flavor was obtained, which he called nicotianine. Later on this product was studied by Posselt and Rieman, and also by Barral. Two formulas have been calculated from Barral's results, namely, $C_{23}H_{32}N_2O_3$ and $C_{36}H_{48}N_3O_5$. Barral states that it yields nicotine on distillation with potassa. This product may possibly be formed from nicotine in the process of sweating, but it is by no means contained in every tobacco. A number of chemists have failed to observe it and the writer has tried in vain to obtain it from Florida tobacco. The aqueous distillate from the Florida tobacco contained, besides small oil drops, some ammonium carbonate, and the precipitate obtained with basic acetate of lead was nothing but lead carbonate.[2] Probably the nicotianine is only an occasional product in very heavy tobacco. Odor as well as aroma is evidently caused not by a single compound, but by a mixture of com-

[1] The word "gum" is applied in other countries in the same sense as the word "life" is with tobacco in America, signifying a certain elasticity of the tobacco leaves. The word "gum" in this connection is derived from the erroneous idea that the elasticity is caused by a content of "gummi elasticum" or caoutchouc. Behrens has recently shown that the "life" of fermented tobacco leaves is due to a greater amount of hygroscopic moisture, caused by a higher percentage of malates of potassa and soda.

[2] The results obtained by the firm of Schimmel & Co., in Leipzig (recently published in Chemiker-Zeitung, 1899, No. 80), are in full accord with the writer's observations. No nicotianine, but considerable ammonia was present in the aqueous distillate of the sweated tobacco tested.

pounds, nicotine contributing in a certain measure to the formation of these.[1]

It was observed by Jenkins, Behrens, Kissling, and others that a certain amount of nicotine (one-fourth to one-third) is destroyed by the process of sweating; hence it is natural to connect the formation of aromatic products with the disappearance of a certain portion of the nicotine. Cured tobacco rich in nicotine may, by a thorough sweat, become poor in nicotine and rich in aroma, while after an insufficient sweat it will be rich in nicotine but poor in aroma.

It is a well-known fact that a high content of nicotine in a cigar is often associated with a poor aroma. Strong cigars are not always the best. But all attempts to produce by partial oxidation of nicotine substances of an aroma similar to that of good cigars have thus far failed. By moderate oxidation, as brought on by silver oxide or hydrogen peroxide, nicotyrine and oxynicotine result, while by a more powerful oxidation nicotic acid is formed—products which have no relation to the odor and aroma of sweated tobacco. The writer has also applied platinum-black as an oxidizing agent. It was left to act for several weeks on a 4-per-cent aqueous solution of nicotine at the ordinary temperature as well as at about 50° C., but the desired effect was not observed, although the nicotine became much altered. Evidently the oxidation, caused by the oxidizing enzyms in the sweating heaps, takes a different direction.

Recent investigations of Thoms[2] have shown that the flavor of the tobacco smoke is chiefly due to an ethereal oil which is produced by dry distillation in the process of smoking from a product of the sweat. Twenty kilos of tobacco, smoked by an aspirator, yielded 75 grams of this oil, which was of a stupefying odor and produced headache and trembling of the limbs when inhaled in a concentrated state. It contained, among other things, 9 grams of a phenol of creosote-like odor.

The best method of avoiding the poisonous action of the tobacco smoke while enjoying its beneficial stimulating effects is found with the Turks, Arabs, and Persians. The use of a wash bottle (nafas) before the smoke reaches the mouth removes a great deal of the poisonous products. Géorgiades found that each 18 grams of tobacco (a pipe full) showed 0.947 gram nicotine, the nafas through which this quantity of tobacco was smoked showed 0.595 gram nicotine, while the washed smoke from same amount contained but 0.0225 gram.

INJURY TO THE AROMA.

The aroma may be injured by various causes, as, for example, by a high content of fat or of protein in the tobacco. Certain tobaccos which

[1] Opinions as to the formation of the aroma are much divided. Van Bemmelen (Landw. Vers. Stat. 37, 388) holds that the organic acids of the leaves have a certain influence.

[2] Chem.-Zeitg., 1899., No. 80.

have a fine odor at the ordinary temperature have but a poor aroma when smoked, since the aromatic substances may be disguised by the products of dry distillation of fat and protein when the cigar is smoked. A high fat content is indeed very injurious. Other compounds also, interfering seriously with the aroma, appear sometimes to be produced under certain climatic conditions. For example, the tobacco produced in Connecticut in the unusually wet season of 1897 was so inferior that the sales did not pay the outlay for fertilizers.[1] The buyers claimed that the cured tobacco had a "stink" about it and that it also showed a similar odor after sweating. Such injurious products seem not infrequently to be present. It is on this account that tobacco is subjected in certain factories to a strong current of air for twenty-four hours at the ordinary temperature, in order to take out the "rank" odor before it goes to the bench for cigar making. Indeed the air which has passed through such tobacco contains a very sharp substance which brings tears to the eyes.

The influence of climate upon the formation of certain products in the tobacco plant may also be inferred from an observation made by Schimmel. While 43 kilograms of tobacco from South America yielded on distillation with water mere traces of a volatile oil, 15 kilograms of German tobacco yielded 6 grams of a thick and dark-colored oil having an odor similar to that of camomile. This oil contained, according to Thoms, no terpens, but it contained among other things a small amount of a phenol. A further injury to the aroma is to be expected from the treatment of the tobacco in the field with paris green and other arsenious preparations to destroy caterpillars. Many tobacco growers avoid the use of such preparations altogether and do not begrudge the extra expense for the labor required in picking off the caterpillars by hand. Others apply Paris green only in the young stages of the plant—1 part well mixed with 100 parts of flour—but in certain districts, where caterpillars occasionally become very numerous, Paris green is applied on the ripening leaves in proportions of about one-fourth of a pound to 40 gallons of water. In one pound of sweated tobacco from such fields M. Peter found from a trace to 1.7 grains arsenious acid.[2] Such tobacco when smoked may be expected to have a disagreeable odor, since even the smallest quantity of arsenious acid produces, in contact with a glowing substance, a disagreeable odor resembling that of garlic. But more serious than the injury to the aroma is the injury to health when such poisoned tobacco is habitually smoked. An injury to the odor of tobacco may also be caused by the development of certain fungi on cigars kept in a too moist atmosphere. Even a putrid odor may thus be produced, as Splendore has observed in one case.[3]

[1] On the other hand too dry seasons are just as injurious, since the tobacco produced may refuse to sweat.

[2] This would correspond to 0.025 per cent arsenious acid or about 0.05 per cent paris green.

[3] Il tobacco, p. 11, 1899.

Numerous experiments have been made to improve the aroma of poor tobacco. Oxidizing media have been applied to destroy supposed injurious by-products. The writer tested the action of a 1 per cent solution of potassium permanganate for five minutes, but the results were not encouraging, on account of the injury to certain other properties.

Other methods consist in the application of substances of powerful aroma. For example, we find among the ingredients for the preparation of petuning liquids anise seed, cloves, cinnamon, coffee, and tincture of valerian.[1] In Cuba tonka beans and vanilla beans are also used to improve the aroma, but with very rank tobaccos even such ingredients prove insufficient. The important question of how to improve poor products deserves careful attention and further detailed study.

NITRITE CONTAINED IN SWEATED TOBACCO.

Although the tobacco of commerce has been the object of frequent and numerous analyses, one compound occasionally occurring in it has thus far been entirely overlooked. It is the nitrous acid present in the form of nitrites. While nitrates frequently occur in various living plants and also in fresh tobacco leaves, nitrites do not. Indeed, these salts would act very poisonously on the living cells if they accumulated to even a small degree. The writer has observed that the poisonous character of free nitrous acid is so great that it kills algæ after one day, even at a dilution of 1 part to 100,000 parts, although its acid character is so weak that it is easily liberated from the nitrites by dilute organic acids, such, for example, as are contained in the cell sap of most plants; hence the salts of nitrous acid are also very strong poisons wherever an acid-cell sap in the plants can liberate nitrous acid from them.

When tobacco leaves rich in nitrates, however, are subjected to the sweating process after being cured a portion of the nitrates is reduced, whereby, as an intermediate step, nitrites are formed, ammonia representing the final product. Some sweated tobaccos are so rich in nitrite that a concentrated extract, even when prepared in the cold, gives a decided odor of nitrous acid upon the addition of sulphuric acid, and even the smallest quantity of the extract produces at once separation of iodine from potassium iodide on addition of a little sulphuric acid. When upon dilution the brown coloration of the tobacco extract is sufficiently diminished, the well-known test of Gries for nitrites is also easily obtained. The tobacco extract containing nitrites gives a blue reaction with tincture of guaiac, but this reaction of nitrous acid is also obtained after boiling the extract for a minute, while the similar blue reaction caused by oxidase is made impossible after heating the extract a short time to 67° C. (153° F.), or, if the extract is weakly alkaline,

[1] Report No. 62 (p. 17), U. S. Department of Agriculture. Marcus L. Floyd.

to 75° C. (167° F.). By this control test erroneous conclusions can be avoided.

An accumulation of nitrites in the sweating tobacco might in the course of some weeks attack the oxidizing enzyms at the temperature of the fermenting heaps, thus terminating this process sooner than desirable. Hence nitrates should not be applied in too large quantities in the manuring of tobacco fields, since they may give rise to the formation of nitrites in the sweating process. Bacterial action need not be assumed in this process.

AMOUNT OF HEAT PRODUCED BY SWEATING IN BULK.

Since the loss of organic substance from the cured leaves in the sweating in bulk amounts to about 5 per cent dry matter, and the cured leaves consist of nearly 40 per cent of carbon and 6 per cent of hydrogen, an approximate calculation can be made as to the amount of heat generated by the oxidization going on in the heap. For an accurate calculation it would be necessary to know the exact amount of carbonic acid and water formed by the oxidation, and further, how much of the carbonic acid was generated from previously present carboxyl groups, and how much water was generated from previously present hydroxyl groups; moreover, it should be known how much total ammonia is produced in the sweat. But, on the assumption that only one-half of the carbonic acid and one-half of the water produced are due to perfect combustion, and that the carbon and the hydrogen in these products show the same proportion as in the cured tobacco, we will obtain numbers which are certainly rather an underestimation than otherwise. The fermenting piles are made up of from 2,000 to 7,000 kilograms of tobacco. Let us assume a pile with 2,000 kilograms of dry matter. The 5 per cent loss after the sweat would then amount to 100 kilograms. According to our assumption this would involve a complete combustion of 20 kilograms of carbon and 3 kilograms of hydrogen. Since one gram of carbon produces 7,678 units of heat and one gram of hydrogen 33,808 units of heat, it follows that 20 kilograms of carbon would yield 153,560 major calories and 3 kilograms of hydrogen 101,400 major calories. This heat would suffice to heat up 254,960 liters of water for 1° C.

CONCLUSION.

Various problems relating to the manufacture of tobacco have been touched upon in this report, some of them within easy reach of solution, others of a very difficult nature. The prevention of fungous attacks in the barn or in the cases, the regulation of the temperature and humidity in the curing process, and the proper control of the sweat are points that can easily be settled. In many cases the replacement of the stalk-curing by the single-leaf curing process may prove a financial success. But there are other problems of a more

delicate and difficult nature, as the prevention of the mosaic or calico disease and the proper composition of the tobacco leaf while ripening. Upon this composition depends the development of a desirable aroma in the sweating process. Climate and weather are here such potent factors that human art can accomplish directly but little. Too cool and rainy weather may favor, for example, the production of fatty matter, which certainly exerts an unfavorable effect upon the aroma in smoking. There may be produced, however, still other products which are unfavorable to the aroma. Too dry weather may also interfere with the proper composition of the ripening tobacco leaves. By crossing and selection, however, varieties of tobacco may possibly be produced that even under unfavorable climatic conditions will not form much of the compounds which injure the aroma. In regard to the selection of the seed, it may be mentioned that even now some farmers go so far as to import their seed directly from Cuba each year.

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U. S. DEPARTMENT OF AGRICULTURE.

Report No. 66.

SHEEP AND WOOL:

A REVIEW OF THE PROGRESS OF AMERICAN SHEEP HUSBANDRY.

BY

J. R. DODGE, Special Agent.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1900.

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LETTER OF TRANSMITTAL.

DEPARTMENT OF AGRICULTURE,
OFFICE OF ASSISTANT SECRETARY,
Washington, D. C., July 5, 1900.

SIR: I have the honor to transmit for your approval, as a report for publication, a manuscript prepared by Mr. J. R. Dodge, formerly statistician of this Department, upon the sheep and wool industry in the United States. The purpose of this report, as I instructed the author, was to review the history and development of the sheep industry in this country and to trace the history of our domestic wool in particular, the variation in prices, and the nature and extent of foreign competition. It has not been possible of course in such a report to eliminate reference to tariff legislation and its general effects on this industry, nor to avoid pointing out in some degree the respective interests of wool growers and manufacturers. In doing so, however, every effort has been made to confine the discussion to the mere facts with as little of argument and theory as possible.

The author has done his work well, and I cordially recommend its publication as Report No. 66 of this Department.

Very respectfully,

J. H. BRIGHAM,
Assistant Secretary.

Hon. JAMES WILSON,
Secretary.

LETTER OF SUBMITTAL.

WASHINGTON, D. C., *July 3, 1900.*

SIR: In fulfilling your commission to investigate the present condition of American sheep husbandry, with a concise and comprehensive review of past progress and its degree of success in meeting the demand for manufacture, I respectfully submit the following report. It touches lightly on the early history of the industry in the colonial period, briefly refers to the eventful era of Spanish Merino importation, and considers the tendencies of breeding to meet the wants of manufacture, the economies of woolgrowing, and the great change in enlargement of production and improvement of quality of mutton. It shows progressively the measure and quality of the domestic wool supply. It traces the periods of decline and revival, analyzes recent tariff changes, compares rates of duty, indicates partially the effects of the free wool era, and closes with a showing of present conditions.

Very respectfully,

J. R. DODGE,
Special Agent.

Hon. J. H. BRIGHAM,
Assistant Secretary.

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SHEEP AND WOOL: A REVIEW OF THE PROGRESS OF AMERICAN SHEEP HUSBANDRY.

BRIEF HISTORY OF WOOLGROWING IN COLONIAL TIMES.

The first settlers in the American colonies in Virginia, in Massachusetts, and in New York either brought sheep with them or with earliest importation of supplies from the native land. With furniture and household equipment came the loom and the spinning wheel. The matrons of the household were weavers and the daughters spinsters. The clothing of the country people was largely of domestic manufacture from wool grown on the farm.

The sheep were mainly from the countries of the settlers—England and Holland. They were of coarse-wool breeds, but not the highly improved breeds of the long and middle wools of to-day. They were of less weight, longer of limb, less compact and symmetrical of body, and of lighter fleece. Those from England were the unimproved progenitors of the mutton breeds, which have been moulded by slow degrees of patient breeding into the present forms.

It is said that the first sheep brought into the colonies landed at Jamestown, Va., in 1609. Settlement was slow and increase of sheep moderate, but in 1649 the number in Virginia was reported at 3,000. There were early importations into Massachusetts, and by 1640 the number was estimated at 3,000. The Dutch brought over sheep to New Netherlands in 1625 and again in 1630. A Swedish colony in 1663 brought 80 into Delaware. All of the colonies introduced flocks and encouraged domestic manufacture of wool.

Colonial legislatures encouraged woolgrowing and manufacture. In 1645 Massachusetts enacted a law for the encouragement of the raising of sheep; and in 1656 one was passed requiring each family to spin three pounds of wool, cotton, or flax per week for thirty weeks of the year. In the same year a skilled weaver, induced by a grant of 30 acres of land, settled in Lowell, Mass., which has since become a great center of textile industry. Virginia, a little later (1662), prohibited the exporting of wool and offered a bounty of five pounds of tobacco (Virginia currency) for every yard of cloth made in the colony. Two years later the general assembly provided for the establishment of looms and weavers in each county. The other colonies enacted laws for the encouragement of woolgrowing and manufacture.

Efforts were early made to encourage weavers and artisans to come from foreign countries and establish a germ of the later factory system by building and operating fulling mills, thus supplementing the results of domestic manufacture. They so increased in the following century that the carding, weaving, and spinning of wool and the dressing of cloth became general in all the colonies before the war of the Revolution.

As the friction between the mother country and the colonies became intense, and the colonies were ripening for the revolution, a patriotic impulse for the wearing of homespun and the discarding of English goods became general. It is said that the Harvard graduating class in 1770 appeared in black cloth of New England manufacture. Similar patriotic impulses actuated colonial officials and professional and business men, and women vied with the men in their patriotic devotion to homespun.

Societies for the promotion of agriculture sought to encourage and promote woolgrowing by essays and premiums. In 1785 a medal was offered by a South Carolina society for the first flock of Merino sheep kept in the State, but it was eight years before the first individual of that breed was imported into any of the States.

Washington was an importer of the improved English sheep. Prominent Virginians took a positive interest in the extension and improvement of sheep husbandry. There were few that were indifferent to a subject so important. Only one, as recorded in the history of the time, the eccentric John Randolph of Roanoke, was so averse to it that he expressed a willingness at any time to go out of his way a mile "to kick a sheep."

In the other colonies the public men were ever the friends of woolgrowing. It was a subject of vital interest to all, as clothing, next to food, is the greatest physical want of humanity. Cotton was scarce and high, and wool for the winter, as flax for the summer, was an ever-admitted necessity of existence. Public men, almost without exception, were favorable to the encouragement by legislation, by premium and bounty, of the manufacture of wool. Societies and a general consensus of public opinion promoted and facilitated personal effort for the extension of woolgrowing and wool manufacture. This was the situation at the time of the establishment of the National Government. There is no record of numbers of sheep, but in proportion to population they may have been nearly as numerous as at present, though not yielding as heavy fleeces. Twenty years afterwards, under the influence of the Merino excitement and a forecast of war, there were, according to the best estimates, more sheep than people, a number larger in proportion to population than at any time since; a number in 1810 as great as would be 100,000,000 for the present population; a number equal to the flocks of Australasia or those of the Plata River countries of South America at the present time.

INTRODUCTION AND IMPROVEMENT OF THE MERINO.

The Spanish Merino is the foundation of the present fine-wool flocks of all countries. This type of sheep antedates the Christian era. Sheep were held in Spain by the king, the nobles, the clergy, and others, and their exportation was prohibited. Until the nineteenth century none could be obtained except by royal favor or by smuggling, which was very difficult. In 1765 three hundred were introduced into Saxony by royal courtesy and were the origin of the Saxon improvement. They were said to be mostly of the Escurial family, assumed to bear the finest wool. Other families were the Infantados, Paulars, Negrettis, Montarcos, Guadaloupes, and Aguirres. The Infantado was a popular breed (progenitor of most American flocks), with soft, silky, and gummy wool; the Paulars were perhaps the handsomest; the Aguirres were better covered in face and legs and the wool was more crimped than that of the Paulars; the Negrettis were tall and homely with wool still more crimped; and the Guadaloupes were tall and rather ungainly with thick crimped wool.

The French Merino had its origin in the breeding of the royal sheep folds at Rambouillet, beginning with 300 imported from Spain by royal favor in 1786. A record of the average weights of their fleeces in the last years of the eighteenth century was from 7 to 9 pounds. This was only the beginning of the improvement that produced the large forms and fleeces of later days.

There is a record of three Merinos, imported in 1793 by Mr. William Foster, of Boston, who gave them to a friend who killed them for mutton. In the first year of this century a French banker, De Lessert, sent four ram lambs to this country, only one surviving, which founded some good grade flocks for his owner, Mr. E. I. Dupont, near Wilmington, Del. In the same year Seth Adams of Zanesville, Ohio, imported a pair of Spanish sheep. In 1802 the American minister to France, Mr. Livingston, sent home two pairs of French Merinos from the royal flock at Chalons and afterwards one from Rambouillet. About 1810 he sold full-blooded ram lambs at $1,000 each and grades at very high prices. He sold the wool of full bloods at $2 per pound, of three-fourths bloods at $1.25, and of half bloods at 75 cents.

Later in the same year Colonel Humphreys, the American minister to Spain, brought home 21 rams and 70 ewes, believed to be of the Infantado family, very carefully selected, and from this importation may be traced some of the finest flocks of the present day. The Atwood strain, now in high repute, originated in a flock founded by Stephen Atwood, of Woodbury, Conn., with stock from the Humphreys importation, which have been bred in great purity to the present day. His first purchase was a ewe bought for $120.

There were small importations in 1803 and 1807. In 1809 and 1810 Mr. William Jarvis, the American consul at Lisbon, Portugal, bought

of the Spanish Junta, from confiscated flocks of Spanish noblemen, and sent to various parts of this country 3,850 Merinos. Fully a third of these were Aguirres; the remainder Escurials, Montarcos, Paulars, and Negrettis. He not only mixed his large flock, but afterwards crossed with the Saxon Merino. Before the cross the average weight of his pure-bred fleeces was 4 pounds. Randall says that 3,500 to 5,000 Spanish Merinos were imported by other persons in 1809, 1810, and 1811.

There was little excitement about the earlier importations up to 1807. Then the difficulties with England and France called attention to the necessity of providing a domestic supply of wool, the embargo intensified popular interest in the matter, and the war of 1812 shut off foreign supplies. It is not strange that prices rose to the extreme of $2.50 per pound for wool and $1,000 or more for a pure-bred sheep. After peace was declared, however, and a flood of foreign goods was admitted, they became a drug in the market at a dollar a head.

The Saxon Merinos were imported in large numbers between 1824 and 1848. During that period this very fine-wool breed had the preference, and the owners of Spanish sheep hastened to obtain a Saxon cross, which reduced the weight of fleece and weakened the constitution of the sheep. The Saxons produced the finest of wool, but they lacked constitutional vigor. Fine flocks have been kept here from that day to this, though few for years past and very few at present. In that Saxon boom their good name was injured by frauds in selling grades for pure bloods. Their failure to sustain their popularity was due mainly to the fact that the price of Saxon wool was not sufficiently high to offset the light weight of fleece.

The great Jarvis flock, in which five families were mixed, was bred, unwisely, to accommodate the manufacturers, sires of a lighter color, the Escurial chiefly, being used instead of the darker-colored or yolkier families. His sheep were more compact than the average Spanish, but much like them otherwise. Some of his ewes yeilded 4 or 4½ pounds of washed wool. This flock finally lost its identity in other breeding flocks.

The Atwood flock was the first example of patient, skillful, and long-continued breeding (from 1813 to 1830). It was built up with careful selections from the Humphreys importation, and afterwards maintained and improved by selection of individuals within the flock. In 1840 the form was Spanish slightly modified, wool short, fine, well crimped, shorter on the belly, not yet fully covering legs and head. Some of the rams had pendulous dewlaps and neck folds or wrinkles. As the Spanish Merino came into especial favor, this flock became popular, and colonies were scattered through the country, especially in New York, some deteriorating, others continuing to improve. This was a

notable beginning, worthy of all praise, but not yet was the American Merino thoroughly established as a new breed of the Merino type.

Though many breeders worked together in the improvement which has developed the most notable and valuable breed of the world, Mr. Edwin Hammond, of Middlebury, Vt., is fairly entitled to be considered the founder of the American Merino breed. He made three purchases between 1844 and 1846, of average selections from the different qualities of the Atwood flock, first breeding in three lines of subfamilies, the dark, the light, and intermediate, afterwards producing his best sheep by crossing these lines with a skill and judgment which entitle him to rank with Bakewell in the long-wool improvement in England. He changed the thin, light-boned, imperfectly covered sheep into models of fine-wool beauty, large, round, low, and strong-boned. The ewes weighed, as reported in 1863, from 110 to 140 pounds, the heaviest fleece weighing 17½ pounds. The ram "Sweepstakes," 1856, sometimes referred to as the origin of the American Merino, as a breed distinct from the old Spanish, had a weight record of 140 pounds and a fleece of 27 pounds.

The extent of the improvement is indicated by measurements made by Mr. Randall in 1861 of individuals of Hammond's flock in comparison with careful measurements in Austria of Spanish sheep at the beginning of the century: American ram, 122 pounds; Austrian Infantado, 104 pounds; American ewes, 100 to 114 pounds; Austrian Infantado, 73 pounds. The Negretti weights were still lower—ram 100, ewe 70 pounds. American measurements of length were 3 feet 11 inches to 4 feet; Austrian Infantado, 5 feet 4½ inches to 5 feet 8 inches. American girth measurements were 4 feet ¾ inch to 4 feet 4½ inches; Infantado, 4 feet 11½ inches to 5 feet. Notice the decrease in length and girth with increase of weight. The neck and legs were shortened and the width of hips was increased. The increase in weight of fleece was extraordinary.

From this initial point the subsequent development and differentiation of this great breed are sketched very concisely in the following chapter.

BREEDING TENDENCIES IN WOOLGROWING AND THEIR EFFECTS.

Nothing is more noticeable in the history of our sheep breeding than the ever-existing tendencies to change. The flocks of one period perceptibly differ from those of ten years later. It is impossible that it should be otherwise, for change is inevitable, and in a country of such resources, enterprise, and ambition as our own this tendency to change is quickened. To meet the requirements of manufacturers for various kinds and qualities of wool, foreign breeds were successively introduced, and they found here a new environment, new conditions

of climate and feeding, which in themselves would induce changes appreciable in a few years. The desire of manufacturers for specific qualities of wool, stimulated by the caprice of fashion in fabrics, also promotes a tendency in breeding to meet such requirements. A further inducement is the ambition of enterprising breeders to make improvements and thus win reputations. While change is not necessarily improvement, the result of breeders' efforts is, on the whole, amid partial failures and successes, favorable to improvement. By going back to the first half of the century and making comparisons we find that great progress has been made—a doubling of the weight of fleece, a greater variety of wool, and much better adaptation to the requirements of manufacturers and consumers of woolen goods.

When the Merino began to assert its sway, to increase rapidly the weight of fleece, and to prove to the satisfaction of the grower that there was money in wool, the temptation was strong to breed to grease in order to give great weight to the fleece, 15 to 20 and even 30 pounds or more. As it was believed that wrinkles, loose folds of skin apparently intended for a larger sheep, would carry more wool on the larger surface, this breeding to wrinkles became a fad. The manufacturer in scouring such wool found its weight a delusion, two-thirds or more of its substance disappearing in the cleansing. He was obliged to discriminate in the price, and eventually the grower found excessive grease and great weights of fleece unprofitable and undesirable; hence wrinkles began to disappear, and sires with smoother though lighter fleeces became progenitors of the flock.

The dawning of the worsted era was observed early in the sixties. There was a great scarcity of English combing wool. England could not fill the demand, nor Canada, and elsewhere the supply was small. Our manufacturers urged the importation of mutton breeds. These sheep were brought in from Canada and from England and scattered through the country east of the Mississippi, giving positive direction to the tendency to increase of the distinctive combing wools of those days.

This did not suffice. There was still a great scarcity, and the quality was coarse. A new era was opening in the worsted industry. At the French exposition of 1867 conspicuous among the wools displayed were some of the Merino race, distinguished for softness and length of fiber, from France and from Australia, derived from French stock. The French Merino, the first of its race to become essentially a mutton sheep and a producer of combing wool of much finer quality than the English combing wool, made possible the fabrication of beautiful goods for women's wear, which gave France a lead in the manufacture of such goods which she has since retained. England could not obtain this wool, and did not attempt the manufacture of this class of goods until it was found that similar qualities could be obtained from Aus-

tralia. The French had already made much progress, of which Renoville wrote concerning the combing wools of France:

> It is to the admirable revolution in the raising of ovine animals that we owe the beautiful industry of spinning the merino combing wools. It is to this that we owe the splendor of the industries of weaving combing wool at Paris, at Rheims, at Amiens, and at St. Quentin.

Great Britain had a successful combing industry of her own. She had no Merino sheep. Combing wool was advancing in price; in 1855 it sold in London for 1s. 1½d.; in 1864 for 2s. 4d. Our own worsted manufacture had been initiated and was successful, but it consumed only 6,000,000 pounds of wool. The wools were grown in Kentucky, in Ohio to a small extent, and elsewhere. No wonder that the dissemination of mutton sheep was urged for the increase of our resources for manufacture and for the meat supply of cities. There was an existing tendency to increase the distribution of English sheep and the production of combing wool by our breeding with Merino grades.

In 1868 Mr. E. R. Mudge, United States wool commissioner, advised the "ingrafting of the French race on the American Merino" as a means of supplying a manufacture which was one of the most important in France and one that was a source of much of the exportation to this country. Specimens of these Rambouillet Merinos were introduced from time to time. They did not at first strike the fancy of breeders of American Merinos, and they did not at once gain favor, but afterwards they won their way and now have a register and are widely scattered throughout the country.

It is not strange that the promoters of the great American Merino improvement should stand aloof from a movement that, as they thought, would degrade the finest wool sheep in the world to a mutton sheep. Yet, feeling the necessity for combing wool, and finding considerable difference in length of fiber in pure-bred Merinos, a few farseeing breeders began to work for longer fiber and a larger carcass, in the direction of mutton and combing wool from the distinctively wool-producing Merino. And this was the starting point from which has been produced, on lines apparently parallel but with distinct and certain divergencies, the subbreeds, the Dickenson Delaine, Standard Delaine, Improved Delaine, National Delaine, Black Top Spanish, and Improved Black Top Merino, all with record books, all pure-bred Merinos, very widely disseminated and now among the most popular breeds in the United States.

Thus has our supply of combing wools been augmented in part from this modification of the American Merino, yielding a soft and lustrous fiber, 3½ to 5 inches in length, suitable for tissues which the coarse combing wools could not produce. This progress has been continuous and persistent during the past thirty years, and in results it has been the most beneficial of the breeding tendencies which have

marked the history of woolgrowing. This course of breeding has given a supply for manufacturing competition with France, in goods requiring much skilled labor in proportion to weight of material, which no dissemination of English breeds could accomplish, and demonstrates the wisdom of the patient breeders who have worked a lifetime to accomplish this result.

The other line of development of combing wools, by increase of pure and crossbred English sheep, has run parallel with the delaine improvement of the Merino. It has been steadily progressive, constantly increasing the supply of coarse combing wools, making the worsted industry nearly independent of foreign wools of class two of the customs schedule. It has also enlarged the supply of material for flannels and certain kinds of cloths from the Down breeds.

In the States east of the Mississippi the mutton breeds have gradually gained a predominance. The southern sheep are always mainly of this class. As population increased in the Ohio Valley meat became more important than wool, and all the mutton breeds were disseminated, taking the place of Merinos, and though fewer in number the average value of sheep in this district has been nearly doubled in the last thirty years from advance in size and quality.

The Southdown, Cotswold, and Leicester were the first to invade this region, followed by the newer Down breeds. The prolific character of the Dorsets later claimed attention from producers of lambs, and twelve years ago they were introduced, and have been distributed in 27 States, 9,000 being registered in the Dorset Sheep Breeders' Association of America. The wool of the Dorset is valuable, strong, white, and nicely crimped. Its scoured fleece is heavy, the loss in scouring being light. The grade Dorset is prolific and profitable in lamb production.

The largest and one of the oldest English breeds was introduced very sparingly until the other mutton breeds had been widely distributed, but in recent years it has become so numerous that a Lincoln Association has been formed to represent it and preserve its purity. The original Lincoln, like the other long wools, was improved by Leicester crossing, diminished in size, improved in form, relieved of coarseness, and increased in aptitude for flesh taking, with finer wool of the lustrous class especially adapted for use in a valuable and desirable class of worsteds. This sheep, so long popular for wool as well as mutton in New Zealand and other Australian colonies, and later in Argentina, has for similar reasons been found desirable here, not only in the farm districts but on the ranges. This breed is largely the basis of the frozen-mutton trade which, in 1897, amounted to 144,657,184 pounds from New Zealand, and 209,172,339 pounds from Australasia altogether. The Argentina frozen-mutton trade is also very large.

A note from Mr. H. A. Daniels, Elva, Mich., secretary of the

Lincoln Association, states "that Michigan contains more Lincolns than any other State—from 4,000 to 5,000." They are scattered through New York, Ohio, Virginia, Missouri, and the Rocky Mountain area. Mr. Daniels reports large numbers of cross-breds on the range, "as the Lincoln has proved the best for crossing on range ewes of Merino descent of any breed, the same as they have been in Argentina." He refers to the large flock of registered Lincolns from England established last year by Colonel Massey, of Fort Logan, Colo.; to one of several hundred purchased in Michigan and Ontario by Forbes Brothers of Boston, and other large pure-bred flocks, as showing the present popularity and rapid dissemination of this valuable breed.

As a result of these continuous tendencies toward combing wools, both fine and coarse, Merino and English, worsted wools now largely predominate in the domestic wool supply. The Merino and English types of sheep are nearly divided as to numbers, the former predominating in the range country, the latter in farming States.

At the present time the tendency of breeding is toward increase of Merinos. The relative scarcity of wools of class one has been apparent for a year or two throughout the world, and in the immediate future there will doubtless be an increase of this breed. This tendency is manifest in this country in all wool-growing districts, even in the Ohio Valley, where mutton sheep predominate and meat is a prime consideration. A letter from Professor Plumb, director of the experiment station connected with Purdue University, Lafayette, Ind., states that the tendency of breeding there is toward the Merino, though the Rambouillet has preference over the American Merino, not losing sight of the value of the carcass while aiming to increase the quantity of fine wool.

The French type will continue in popularity, and the Delaine breeds will be disseminated more generally than at present; and, while clothing wool may increase, it is evident that the value of the mutton, in connection with wool, is not likely to be lost sight of, even in the breeding of the Merino. In breeding for fine clothing wools, plumpness and symmetry will be preferred, rather than wrinkles and grease, and smoothness of outline and thrift of growth will be desirable characteristics.

Our climate is favorable to the highest ovine development. Foreign breeds have been easily acclimated and manifestly improved. It is certain that the American sheep has no superior in any woolgrowing country, in constitutional vigor and strength of wool fiber. No other wools make more durable and intrinsically valuable clothing. American wool consumption should be mainly of American production. Manufacturers know that their prosperity depends upon a full domestic wool supply, and will cooperate with the growers in encour-

aging the production of wool to meet all ordinary requirements of clothing, both cloths and worsteds.

INCREASE OF MUTTON SHEEP.

In the colonial period the sheep were all of the coarse-wool type, brought with the settlers from the countries of their nativity. They were the unimproved original stock, the progenitors of the present improved English breeds. Later Washington and other fathers of the Republic brought in individuals representing the early breeding improvement in Europe. No Merinos came in until after the organization of the National Government. The Merino importation in the present century and the establishment of the American Merino breed in a half century of breeding to build up an American wool industry so popularized that breed as to give it a largely predominating influence forty years ago. Thirty years ago more than four-fifths of all the sheep in the country were either pure-bred or grade Merinos. There were a few Downs and specimen flocks of various long-wool breeds, small in number, in the Middle States and in the Ohio Valley and scattered sheep of the old coarse-wools in the South. Kentucky had the largest number of the long-wools. There was some importation from England and more from Canada. In Texas and New Mexico there were some Mexican sheep of Spanish origin, degenerated and almost reverted to a wild state. Their fleeces, coarse and hairy, weighed only a pound or two. Possibly all these together were not more than 15 per cent of the whole. There is no exact census of the coarse-wooled sheep of that period, those having no Spanish Merino blood, yet the almost universal predominance of that type and the character of the wool appearing in the markets of those days will amply sustain this view as conservative and sufficiently accurate.

For at least thirty years there has been a tendency—strengthening as the years roll on and helped by the steady and rapid increase of population demanding meat—toward increase of coarse-wool sheep, enlargement of mutton production. Even earlier a greater need of worsted wools was felt, and the initiative was taken toward their supply. This transformation of flocks would have been more rapid but for the discovery that Merino wools of long fiber could be combed, which stimulated the adaptation of special machinery by manufacturers and the gradual lengthening of Merino fiber by breeding on the part of the growers. The writer of this as early as 1862 urged that the American farmers should seek a profit in mutton and wool rather than in wool alone; that the great want of the world was "a strong, serviceable, long-fibered combing wool, and a great deal of it." In 1866 an estimate submitted to the revenue commission made the value of the annual product of worsteds, exclusive of delaines, $10,000,000.

In 1867 Mr. Mudge, commissioner of wools and woolens at the Paris

exhibition, said to the woolgrowers of this country "that there is a field more vast than their imagination can take in in the expansion of the worsted industry." Under such inducements the flocks of mutton sheep increased in all parts of the country, though Merino improvement was still the predominant feature in sheep husbandry in Vermont, New York, Pennsylvania, Ohio, Michigan, and elsewhere, and the great flocks of the Territories became Merino grades of a high order of improvement. But the great breeding flocks were improved largely in the direction of Delaines, producing a fine combing wool of gradually increasing length of fiber.

During the past ten years the increase of mutton breeds has been more rapid than ever. They predominate in all the older States east of the Rocky Mountains. In the mountain States many have been introduced in recent years, sires of English breeds being procured to produce cross-bred mutton in place of wool alone. In this way the breeders hoped to turn their flocks into mutton sheep and obtain a profit they could not get from wool. It seemed feasible, but so many were thrown upon the markets as meat that prices fell and discouragement continued. In the central West numbers of sheep have been greatly reduced, yet they are nearly all of the mutton type.

Mr. Avery, of Mauger & Avery, Boston, than whom no dealer in wool has better facilities for knowing the character of American flocks, writes that at least 70 per cent are medium cross-bred wools, and possibly 80, and the remainder Merino or its grades. He estimates the wool of the ranges as 30 per cent medium crossbred and 70 per cent Merino. Other dealers, in Boston and Philadelphia, furnish information showing the great predominance of coarse wools east of the Mississippi.

Messrs. Hecht, Liebmann & Co. of Boston, who deal very extensively in "Territory" wools, state that most of their wool is Merino, much of it pure or nearly so; in rarer cases it is crossed once, sometimes twice, with Lincolns, Shropshire, or other coarse-fibered English stock. They say:

> The wools we receive from eastern Oregon, California, Nevada, western Idaho, southern Utah, and Texas seem to be as purely Merino as it is possible to grow them, without producing unmarketable mutton. On the other hand, wools received from certain parts of Oregon, southeastern Idaho, northern Utah, and western and northern Wyoming are distinctly crossbred, and show, from year to year, a gain in English blood. We do not receive any wool that is wholly of English blood, except an occasional ram fleece.

It appears probable, from information derived from many sources, that about half of the sheep of the country are now of English breeds or grades in which that blood predominates.

Those who have watched the great Western markets have seen abundant evidence of higher appreciation of mutton than formerly, in active markets and higher prices. During the present season the

average price of mutton in the Chicago market has ranged higher than that of beef, and at times the quotations for prime native wethers have been higher than for extra prime steers.

A noticeable feature of the mutton trade has been the demand for Colorado lambs. It was discovered that the Mexican lambs improved by crossbreeding, and fed a few months in winter with corn and alfalfa made meat of high quality, which has become so popular that it is sought as a delicacy by managers of hotels of the seaboard cities from Boston and New York to Florida. These lambs sell in Chicago for $7.50 to $7.75 per 100 pounds. The business of feeding has been very profitable, and much money has been made in it. Some feeders have had thousands in their yards at a time, and some young men with small means and a little credit with local banks have made handsome profits. Clay, Robinson & Co. of Chicago estimate the annual output of these lambs fed in Colorado at 350,000, with as many more under similar feeding at other points. At $6 per head, this would make a total of $4,200,000 for this peculiar development of mutton production. The preferable live weight of these lambs is about 80 pounds, which is not far from the average.

The mutton breeds are very prolific, and the number of lambs with proper care is 100 per cent of the number of ewes. Always a large proportion of the lamb crop of the farming districts and not a few in ranch districts are every season consumed locally as spring lambs, or appear in markets through the year, being usually known as lamb until a year old.

An indication of the rapid increase and large volume of marketing of sheep is found in the records of receipts of four principal Western markets, at different periods, as follows:

Number of mutton sheep received at principal Western markets at different periods.

	1870.	1880.	1890.	1899.
Chicago	349,853	335,810	2,182,667	3,682,832
Kansas City	.....	50,611	535,869	953,241
Omaha	.....	.....	156,186	1,086,319
St. Louis	94,477	205,969	358,496	432,566

Here is an increase in thirty years from less than 500,000 to more than 6,000,000, and over 5,000,000 were slaughtered in these four cities. Other cities in the West slaughter considerable numbers, the great seaboard cities kill large numbers, besides consuming refrigerated carcasses from the West, and every town and village in the country has a market for live sheep and lambs. On nearly a million farms and ranches where sheep are grown, mutton is a prominent resource for meat consumption.

A similar change in distribution of mutton sheep has been observed in all wool-growing countries. A strong inducement has been found

in the demand for mutton in Great Britain, which has given rise to the frozen meat trade of New Zealand and Argentina. Heavy importations of English mutton sheep have been in progress in those countries for years, until nearly half their flocks are crossbred. Messrs. Helmuth, Swartze & Co., of London, in reporting the relative proportion of crossbred and merino wools, show an increase of the former from 17.7 per cent in 1888 to 44.6 per cent in 1898 in the colonial and Plata River wools, as given in the following statement in millions of pounds of clean wool:

Relative increase and decrease of crossbred and Merino wool.

Year.	Crossbred.		Merino.		Total millions of pounds.
	Millions of pounds.	Per cent.	Millions of pounds.	Per cent.	
1888	70	17.7	325	82.3	395
1892	98	19.6	402	80.4	500
1897	232	39.6	354	60.4	586
1898	248	44.6	308	55.4	556

The result of so radical a change throughout the world has caused the relative appreciation of merino wool. There is in all markets a comparative scarcity of fine wool, and a demand for increase to which breeders are now responding.

Under present conditions, however, the production of mutton in this country will continue to be profitable, and should be, in some of its branches, one of the important rural industries of our oldest and most populous States.

The present distribution of mutton sheep is more general than ever before. They have invaded the pastures so long sacred to the development of the American Merino in Vermont, and the strongholds of Merino breeding in New York, Ohio, and Michigan. They have nearly driven out the fine-wool competition in Indiana and Illinois, and taken possession of sheep pasturage on the meat-producing prairies of the Missouri Valley. This movement has long been in progress. In the recent period of depression, when growers would fain have ceased to think of sheep as a wool-bearing animal, the mutton sheep hastened its migration to the ranges of the Rocky Mountains, and essayed the muttonizing of Merino flocks by cross-breeding. So active and persistent was this effort to get some profit from meat, where wool failed to pay the cost of shearing and growing, that in the entire range country 30 per cent of flocks were of mutton breeds, according to the estimate of Mauger & Avery, wool dealers of Boston, who are familiar with the stocks of the greatest wool markets in the country. The same authority thinks that in the farming States 70 and perhaps 80 per cent of the wool is from sheep in which the

blood of the English breeds predominates. This would indicate a nearly equal division of the Merino and English races in the United States.

THE DOMESTIC WOOL SUPPLY.

The use of wool is coincident with the use of clothing. The first white settlers of this country brought with them the domestic loom and spinning wheel. For more than a century and a half, household manufacture held universal sway. The fulling mill supplemented its operations and suggested the factory to come. This was the condition when the United States Government went into operation and for some time thereafter.

The consumption of wool in this country has always been relatively large. Prior to the beginning of the factory era, however, consumption averaged not more than 3 pounds per capita of population. Fifty years ago the requirement had risen to 4 pounds. As wealth increased and styles of fabrics multiplied, the uses of wool enlarged, until, at the present time, with velvet tapestries for the home and luxuries in worsted for its presiding genius, the requirement per head has risen to about 8 pounds. No other people use so much wool, as also none use so much cotton. The wool of the world will scarcely suffice for 2 pounds annually for each of its inhabitants. Our rate of consumption has doubled in half a century, but it has not increased in the last ten years and may not increase in the future.

About two-thirds of our present mill consumption is supplied from domestic sheep, and a larger proportion very soon will be, as numbers of sheep are rapidly increasing. Including imported manufactures, the domestic supply is now fully half the entire consumption of wool products and promises soon to be two-thirds. Between 1880 and 1890 the proportion of domestic wool was larger, being nearly six-tenths of all needed. In value the proportion was still larger, the imported wools for manufacture being mostly of a much lower quality, largely used for blankets and carpets. There should be no difficulty in so enlarging the domestic supply as to meet the requirements of consumption of nearly all the cloths, worsteds, knit goods, and at least the better class of carpets. The only practical limitation of a full supply of everything is from economic causes.

We have already nearly all the improved breeds of the world, and a great variety of the climates and grasses of the world. If we do not produce much of the finest Saxony wool it is because heavier fleeces are more profitable. Wool of this class has compared favorably with the finest ever produced in Saxony, and flocks of this class are still in existence, some of the finest being in Washington County, Pa. Our Mexican sheep yield a typical carpet wool, but crossed with the Merino a heavier fleece of more valuable wool is produced, and growers find profit in the improvement. When we produce 500,000,000

pounds or more of domestic wool, some of the coarsest fleeces and the least valuable pieces of sorted fleeces can supply the material for the better class of carpets, and the coarsest of the wools of lower civilization and unimproved agriculture may be received, under proper safeguards, to supplement the wants of the carpet industry.

For strength and durability American wools are unsurpassed, and make more durable clothing than the average product of any other nation. In this respect they are superior to Australian wools, which suffer loss of strength from the effects of a hot and dry climate. The flocks of those colonies have been recruited from American Merinos largely, and of late many are crossed with English Lincolns and other breeds to meet the demands of fashion for lustrous wools. This in part, but mainly the light shrinkage, owing to the smaller quantity of grease to be eliminated, makes the higher prices of Australian wool as compared with heavy-shrinking merino wool. The method of marketing, sorting by the skirting process, has also added much to prices of these wools for ten years past.

American sheep have long been appreciated abroad. As early as 1851, at the London World's Exhibition, four prize medals were given to American sheep, and at the Hamburg International Exhibition of 1863, in competition with representatives of the finest flocks of Europe, two first-class premiums were awarded to Merinos from Vermont. Ever since then our American Merinos have been drafted into the service of countries in wool-growing development, notably in the Australian colonies and in South America.

The enumeration of sheep was not made by the census until 1840, when the number reported was 19,311,000. For twenty years there was little increase. In 1850 the number given was 21,773,000, and only 22,471,275 in 1860. Prior to 1840 no very accurate estimates are available. There had been a great boom in sheep in the early years of the century, when Spanish Merinos began to be imported. Independence of foreign wool became an intense and pervading feeling in the years preceding the war with England, and a determined effort for a full domestic supply was made. An estimate for 1810 places the number of sheep at 10,000,000, and the value of manufactures—domestic manufactures, as only a few small factories were then in existence—was estimated at $25,000,000. If correct, it must be that prices of goods were very high. After the war of 1812 the sheep industry was nearly wiped out as the result of a deluge of cheap woolen goods, and it was several years before the numbers of 1810 were again attained.

Between 1860 and 1870 a very rapid advance was made, from about 22,000,000 to possibly 42,000,000, followed by a decline in the later years of the decade to 31,000,000. Annual estimates were made by the Department of Agriculture, not including the mountain areas till nearly the close of the decade, when statistical service was organized

in the great ranch districts. The figures were therefore not complet in those years. After this disturbed and fluctuating record the esti mates became more reliable and the development more uniform. Th following table presents this record, with estimates of wool produced from 1871 to the present time:

Number, average value, and total value of sheep in the United States, and amount of woo produced, 1871–1900.

Year.	Number of sheep.	Average value.	Total value.	Pounds of wool.
1871	31,851,000	$2.32	$74,035,837	153,000,000
1872	31,679,300	2.80	88,771,197	150,000,000
1873	33,002,400	2.96	97,922,350	158,000,000
1874	33,938,200	2.61	88,690,569	170,000,000
1875	33,783,600	2.79	94,320,652	181,000,000
1876	35,935,300	2.61	93,666,318	192,000,000
1877	35,804,200	2.26	80,892,683	200,000,000
1878	35,740,500	2.26	80,603,062	208,250,000
1879	38,123,800	2.07	79,023,984	211,000,000
1880	40,765,900	2.21	90,230,537	232,500,000
1881	43,576,899	2.39	104,070,861	240,000,000
1882	45,016,224	2.37	106,595,954	272,000,000
1883	49,237,291	2.53	124,365,835	290,000,000
1884	50,626,626	2.37	119,902,706	300,000,000
1885	50,360,243	2.14	107,960,650	308,000,000
1886	48,322,331	1.91	92,443,869	302,000,000
1887	44,759,314	2.01	89,872,839	285,000,000
1888	43,544,755	2.05	89,279,926	269,000,000
1889	42,599,079	2.13	90,640,369	265,000,000
1890	44,336,072	2.27	100,659,761	276,000,000
1891	43,431,136	2.50	108,397,447	285,000,000
1892	44,938,365	2.58	116,121,270	294,000,000
1893	47,273,553	2.66	125,909,264	303,153,000
1894	45,048,017	1.98	89,186,110	298,057,384
1895	42,294,064	1.58	66,685,767	309,748,000
1896	38,298,783	1.70	65,167,735	272,474,708
1897	36,818,643	1.82	67,020,942	259,153,251
1898	37,656,960	2.46	92,721,133	266,720,684
1899	39,114,453	2.75	107,697,530	272,191,350
1900	41,883,065	2.93	122,665,913	[1]290,000,000.

[1] Estimated.

In fourteen years from 1871 the increase was about 60 per cent. From 1885 to 1889 numbers declined, increased again until 1893, then fell off again until 1897. Increase is now regular, with the likelihood of reaching a higher figure than has been heretofore attained.

Increase in numbers of sheep has not always represented the increase of the domestic wool supply. Improvement by breeding and by better care has more than doubled the weight of fleece. The census of wool is probably not so accurate as that of sheep, but a comparison of the different enumerations shows a steady and rapid increase in weight, in dividing the reported quantity of wool by the number of sheep.

The steady increase in the weight of fleeces is the result of a stronger infusion of Merino blood in clothing-wool flocks, and the improvement in Mexican and other low-grade sheep by the use of sires of English mutton breeds. Better care and feed have also increased the weight of fleece. As indicated by the census enumeration, the average weight has been 1.9 pounds in 1840, 2.4 in 1850, 2.7 in 1860, 3.5 in 1870, 4.4 in 1880, and 4.8 in 1890.

While the census returns of wool are doubtless somewhat low, the

averages indicate an increase that is well understood by woolgrowers. Expert investigation shows somewhat larger averages, which have quite regularly increased until the present average comes within a small fraction of 6 pounds per fleece. It should be understood that the fleeces shorn from the sheep on the farm do not constitute the full domestic wool supply. The millions of sheep and lambs slaughtered are either shorn before slaughtering or the pelts afterwards furnish a considerable quantity of pulled wool, so that the entire year's supply of wool is taken from a much larger number of sheep than any census or assessors' enumeration gives.

The distribution of sheep at the present time is indicated by the following estimates of numbers and average values in January, 1900:

Numbers and values of sheep, January 1, 1900, by States and Territories.

States and Territories.	Number.	Average value.	Total value.
Maine	254,027	$3.10	$787,484
New Hampshire	79,072	3.19	252,239
Vermont	169,259	3.61	611,363
Massachusetts	40,194	4.55	182,883
Rhode Island	10,608	3.86	40,974
Connecticut	31,808	3.90	124,194
New York	846,165	4.07	3,448,122
New Jersey	42,722	4.34	185,584
Pennsylvania	814,322	3.60	2,928,302
Delaware	12,592	3.67	46,269
Maryland	138,177	3.51	485,553
Virginia	376,918	3.09	1,164,676
North Carolina	235,260	1.62	379,945
South Carolina	61,217	1.70	104,069
Georgia	294,826	1.76	518,893
Florida	76,074	1.69	128,870
Alabama	171,799	1.53	262,767
Mississippi	215,748	1.56	335,490
Louisiana	113,205	1.58	179,203
Texas	2,416,721	1.92	4,634,063
Arkansas	108,957	1.67	181,795
Tennessee	251,735	2.37	596,485
West Virginia	426,814	3.19	1,363,244
Kentucky	549,832	3.01	1,656,094
Ohio	2,839,690	3.71	10,535,250
Michigan	1,389,073	3.58	4,972,882
Indiana	677,905	4.00	2,713,993
Illinois	637,719	3.97	2,532,383
Wisconsin	744,656	3.65	2,716,505
Minnesota	419,218	3.18	1,333,113
Iowa	619,476	4.02	2,487,816
Missouri	597,619	3.10	1,854,711
Kansas	275,118	3.04	835,534
Nebraska	322,057	3.39	1,090,807
South Dakota	381,882	3.29	1,257,156
North Dakota	374,110	3.16	1,183,683
Montana	3,884,179	2.84	11,017,474
Wyoming	2,840,190	3.51	9,964,806
Colorado	2,185,327	2.86	6,250,036
New Mexico	3,973,439	2.17	8,622,362
Arizona	1,024,430	2.31	2,393,581
Utah	2,370,983	2.59	6,150,330
Nevada	657,773	2.91	1,914,120
Idaho	2,658,662	2.80	7,444,254
Washington	790,217	3.13	2,470,218
Oregon	2,446,695	2.67	6,532,676
California	2,001,501	2.85	5,710,282
Oklahoma	33,094	2.52	83,380
Total	41,883,065	2.93	122,665,913

A great change has occurred in the distribution of sheep in thirty years. In 1870 the mountain range country was just emerging from

the control of the Indians, and, with the Pacific coast and Texas, contributed only 22 per cent to the Department estimates of 1871; now the above table gives to this Western range section about 65 per cent of all, or more than 27,000,000 sheep. Then Texas was beginning to make progress in sheep husbandry, which was so rapid that in 1884 the record made an aggregate of nearly 8,000,000, the highest ever made by that or any sister State. That of last January was 2,416,721, a figure exceeded by New Mexico, Montana, Wyoming, Idaho, and Oregon.

These facts indicate the relative decline of sheep husbandry in the farming States. The free pasturage of the great range country handicapped the industry on farm lands, especially the woolgrowing branch. Just as wheat growing gradually receded westward, and cattle raising declined, first east of the Alleghenies and afterwards appreciably in the Ohio Valley, woolgrowing almost disappeared from the farms, while mutton production lingered in the blue-grass section and other regions of fat pasturage, and the raising of early lambs retained a footing among farmers skilled in this branch of meat making. A few of the skilled and experienced breeders of Vermont, New York, Pennsylvania, and Ohio continued the development of pure-bred Merinos for the improvement of the flocks of the range country, and those of South America and Australia. With increasing demand for mutton, the flocks of the farming States were gradually modified by a larger infusion of the blood of the English breeds. Thus the balance of distribution was disturbed, notwithstanding some advantages in high breeding and nearness to mutton markets.

The Central West was long a stronghold of woolgrowing. It gave way to powerful far Western competition slowly, holding its position tenaciously, and yielding only as other industries and interests demanded recognition and commanded better profit. The following statement compares the present with the distribution of 1871:

Number and value of sheep in Central West in 1871 and 1900 compared.

States.	1871.			1900.		
	Number.	Average value.	Total value.	Number.	Average value.	Total value.
Kentucky	904,300	$2.53	$2,287,879	549,832	$3.01	$1,656,000
Ohio	4,641,000	2.26	10,488,660	2,839,690	3.71	10,535,200
Michigan	3,072,800	2.23	6,852,344	1,389,073	3.58	4,972,800
Indiana	2,103,000	1.82	3,822,000	677,905	4.00	2,715,000
Illinois	1,424,000	1.98	2,819,520	637,719	3.97	2,532,000
Wisconsin	1,056,000	2.44	2,576,640	744,656	3.65	2,716,000
Minnesota	140,000	2.22	310,800	419,218	3.18	1,333,000
Iowa	1,822,700	1.71	3,116,817	619,476	4.02	2,487,000
Missouri	1,578,200	1.61	2,540,902	597,619	3.10	1,854,000
Total	16,742,000	2.08	34,815,562	8,475,188	3.58	30,802,000

In 1871 the estimated number of sheep in the country was 31,851,000; in 1900, 41,883,065. The proportions of these States at the two dates

are respectively 52.6 and 20.2 per cent. And the numbers in these States were by no means highest in 1871. Ohio had 7,000,000 a few years earlier. Although there are little more than half the number now that was reported in 1871, it is noticeable that the total value is greater now than then. This is only in part because of increase in average value of sheep in the whole country from $2.32 in 1871 to $2.93 in 1900. The increased average value of the sheep in the central West is largely due to increase in the number of heavy mutton sheep and the value of pure-bred heavy Delaine Merinos. The decrease in numbers has only one exception—Minnesota, which in 1871 had very few farm animals of any kind. There is no reason why the flocks of this section should not be increased, not for wool alone, but for mutton and wool, and the tendency is now strongly in that direction.

There is no doubt of the ability of our woolgrowers to produce a full supply of clothing and worsted wools. Of this the manufacturers have long been satisfied. Thirty years ago a president of the Wool Manufacturers' Association expressed his opinion that "the consumption of American wool, now about 125,000,000 pounds, will in six years aggregate more than 300,000,000 annually." It was not accomplished in six years, but in 1884 the supply reached that figure. This desire for a full domestic supply on the part of wise and far-seeing manufacturers was founded on the superior qualities of American wool, and also on the necessity of independence of foreign wool markets. Foreign manufacturers are compelled to depend on imported wools mainly, to scramble for supplies in all the woolgrowing countries of the world. Our manufacturers realize the advantage of nonparticipation in this competitive quest on antipodal continents and the islands of distant seas for wools, none of which are better than our own, and most of which are weaker in fiber and of less durability. Thirty-four years ago, at the very beginning of the era of improvement by breeding and better care, a committee of the National Association of Wool Manufacturers, consisting of the most experienced and successful manufacturers of the United States, said in a report:

> In a class of fabrics entering more largely, perhaps, than any others into general consumption, that of flannels, their superiority, due principally to the adaptation of the common wools of this country, their strength and admirable qualities, is so marked as almost to exclude the foreign flannels. American fancy cassimeres compare favorably in finish, fineness, and strength with those imported. Our delaines, owing again in a great measure to the excellence of our Merino combing-wool, surpass the fabrics of Bradford at the same price. The excellence of American shawls was admitted at the great exhibition at London.
>
> It has been the experience of all nations that the domestic supply has been the first and always the chief dependence of its manufactures, and the peculiar character of the material has impressed itself upon the fabric which each country has produced. Thus, in the fine wools of Saxony and Silesia we have the source of German broadcloths; in the combing-wools of England the worsteds of Bradford, and in the long Merino wools of France the origin of the flannels and cassimeres. The peculiar

excellencies of Merino wools have given origin to our flannels, our cassimeres, our shawls, and delaines, and they give soundness and strength to all the fabrics into which they enter.

Since that time the delaine improvement has been remarkable, the Rambouillet, or French Merino, has become popular, the Lincolns and Cheviots have been added to the Leicesters, Cotswolds, and the Down breeds, the stocks of the mutton type have become more numerous, and even the fat-tailed Tunis has a footing among our breeds, which now include nearly all worth noting in the world, so that our wools are greater in variety than ever before. Nearly thirty years ago the writer said of the Rambouillets: "The introduction of these regenerators, which have proved so efficient in Australia and Buenos Ayres, might well again be essayed." The better care and better feed that is now bestowed on all our farm animals extends to sheep and affects favorably the character of the wool. This liberal and systematic feeding produces a uniform, sound, and healthy fiber.

Mr. E. B. Bigelow, the first president of the Manufacturers' Association, stated "that the card-wool industry constituted the larger part, probably four-fifths of the whole," and that "the principal hindrance to the rapid extension of this branch of manufacture is the limited supply of raw material," and that "there is nothing that would give such an impetus to the manufacture of worsted fabrics in this country as a full supply of home-grown long combing-wools." The introduction of the mutton breeds above mentioned and their wider dissemination has done much to remedy this deficiency; but the introduction of the French Merino and the great improvement wrought by selection and breeding of our Delaine Merinos, which are differentiated now in fixed characteristics and established as distinct breeds with books of record, has given us a wealth of home-grown material for worsteds such as no other country enjoys.

The supply of wool for consumption is made up of the domestic product and net importation, or imports minus exports. An approximate estimate for the decade between 1840 and 1851 is 60,000,000 pounds, or 3 pounds per capita; for the decade between 1850 and 1861 about 90,000,000, or about 3½ pounds per capita. For the four decades since 1860 annual estimates of sheep and wool have been made, from which the following statement of supply has been made:

Domestic and foreign wool supply of the United States, by decades, 1861–1900.

Fiscal years.	Domestic.	Foreign.	Total.
	Pounds.	*Pounds.*	*Pounds.*
1861–1870	1,387,586,407	501,611,132	1,889,197,539
1871–1880	1,861,226,971	640,916,638	2,502,143,609
1881–1890	2,805,850,348	889,005,571	3,694,855,919
1891–1900	2,831,090,691	1,614,052,056	4,445,142,747

This table marks the progress of woolen manufacture and shows that more than twice the quantity of wool manufactured in the sixties is now required and that the mill consumption has advanced per capita from 5.4 to 6.4 pounds.

The foregoing summary gives the net importations by decades for forty years. For the last ten years more detail is desirable, and the following table gives the annual importation according to the tariff classification, showing the proportion of clothing, combing, and miscellaneous cheaper wools:

Amounts, kinds, and values of wool imported into the United States, 1891–1900.

Year ended June 30—	Clothing wools.		Combing wools.		Carpet and other similar wools.		Total.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
1891	32,230,935	$6,919,913	6,667,023	$1,551,490	90,405,690	$7,759,969	129,303,648	$18,231,372
1892	50,262,796	9,523,773	5,826,574	1,368,654	92,581,282	8,795,681	148,670,652	19,688,108
1893	43,311,565	7,876,676	6,736,201	1,466,641	122,386,072	11,720,863	172,433,838	21,064,180
1894	10,685,496	1,748,359	1,548,505	399,875	42,918,584	3,959,204	55,152,585	6,107,438
1895	87,151,522	13,335,602	13,476,735	2,637,581	105,405,649	9,583,238	206,033,906	24,565,421
1896	117,233,440	19,448,471	15,756,318	3,509,736	97,921,715	9,493,035	230,911,473	32,451,242
1897	200,759,079	34,281,656	37,951,490	7,187,620	112,141,457	11,773,915	350,852,026	53,243,191
1898	45,442,987	7,969,611	4,320,873	859,599	83,031,342	7,954,482	133,795,202	16,783,692
1899	12,976,999	1,948,954	2,155,419	587,061	61,603,791	5,786,882	76,736,209	8,322,897
1900	37,404,243	8,009,985	12,631,283	2,638,721	105,882,929	9,617,230	155,918,455	20,265,936

This makes an importation in ten years of 1,659,807,994 pounds, of which about one-half was received in a little more than three years as free wool, twice as much as the usual average under the dutiable schedules. The worst aspect of this abnormal increase is the large proportion of clothing and combing wools under the law of 1894, more than two-thirds of all the receipts for ten years coming during this period. These are the wools that compete most seriously with the domestic product.

To show the amount of wools imported at the present time and the countries from which they are imported the following statement covers imports of clothing wools, or those of the Merino type, for the fiscal year ended June 30, 1900:

Amounts and values of clothing wools (class 1) imported in fiscal year ended June 30, 1900, by countries from which imported.

Countries.	Amount.	Value.
	Pounds.	
United Kingdom	18,131,387	$2,602,068
France	109,196	13,998
South America	12,035,380	2,257,710
Asia and Oceania	11,013,793	2,934,126
Other countries	1,114,487	202,083
Total	37,404,243	8,009,985

Though Great Britain makes the largest shipments the wool is not grown there, but comes mostly from Australia, with some contributions from South Africa and the Plata River region of South America.

The combing wools (class 2) are always a relatively small quantity, our various families (now recognized as breeds) of Merino Delaines producing a finer combing wool than the English breeds and furnishing much of the present supply. Class 2 includes the wool of these mutton breeds, and comes mostly from Great Britain, the home of the mutton sheep, though much of this may have been brought to London from the mother flocks of New Zealand and Argentina. Canada makes the next largest contribution to our imports of English combing wools. The following statement shows the sources of these foreign wools:

Amounts and values of combing wools (class 2) imported in fiscal year ended June 30, 1900, by countries from which imported.

Countries.	Amount.	Value.
	Pounds.	
United Kingdom	9,445,222	$1,885,529
Other Europe	779,630	271,662
British North America	2,135,929	418,503
South America	206,472	48,600
Asia and Oceania	25,840	7,102
Other countries	38,190	7,325
Total	12,631,283	2,638,721

Class 3, miscellaneous wools, sometimes miscalled carpet wools, are the product of neglected flocks and unskilled breeding throughout the world. Some of these wools can be and have been used for coarse flannels, and some can be utilized in cheap cloths. As our carpet industry is flourishing, and so far held its own in the great depression of manufactures as to supply domestic consumption and keep out all but a few fancy weaves and special orders, most of this cheap stuff, costing less than an average of 10 cents per pound, and some of it not more than 7, necessarily goes chiefly into carpets. Indeed, in the manufacture of the best grades of carpets better wool is sometimes used. The wool of class 3 comes from the following countries:

Amounts and values of wools of class 3 imported in fiscal year ended June 30, 1900, by countries from which imported.

Countries.	Amount.	Value.
	Pounds.	
United Kingdom	29,349,316	$3,199,216
France	3,784,008	375,298
Germany	2,187,716	233,117
Other Europe	21,660,166	1,988,625
British North America		
South America	10,608,902	796,982
China	30,709,966	2,157,573
Other Asia and Oceania	7,138,676	823,896
Other countries	444,179	45,523
Total	105,882,929	9,617,230

The year ended June 30, 1900, has been one of remarkable activity in manufacture. The output has been unprecedented, yet the impor-

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tations of wool in the three fiscal years, 1898–1900, have been less than one-half as much as the importations of the preceding three years. There has been wool used of previous importations because the glut had to be cleared away and the destruction of sheep had caused an insufficiency of the domestic product; yet there is reason to believe that in the presence of a full domestic supply of clothing and combing wools there would be no very urgent demand for the importation of any large quantity of wools except those of class 3.

It is indicative of the high standard of living in the United States that the consumption of wool in domestic and imported goods has increased in fifty years from 4 to 8 pounds per head.

While our importations of manufactures of wool have increased in each decade for fifty years, except the last, the value per capita of imports has been diminishing with much regularity for fifty years. For the ten years ended with 1860 this value per capita was the highest in the history of our foreign trade, $1.16; in the following decades, respectively, 94, 90, 74, and 46 cents. A heavy decrease is noted in the last decade, an effect, as the writer believes, of legislation tending to restrict importation and to stimulate domestic production. This is the more notable from the fact that the average annual imports of the free-wool period were nearly double those of the other seven years, being $47,065,760, although the prices were low and quantities of low-class goods correspondingly large. There were never so many goods before imported in three years, and they never were of so base a quality. Yet the reduction in value of imports since 1890, as compared with the previous decade, is 26 per cent, while our population has been increased about 20 per cent.

This affords a guaranty of our ability to produce all the woolens required for consumption. The machinery at present in operation is deemed sufficient, without much extra speeding or increase of running time, to supply the wants of a full rate of consumption.

Value of net importations of manufactures of wool by decades, 1830–1900.

Ten years ended with—	Aggregate.	Annual average	Average value per capita.	Ten years ended with—	Aggregate.	Annual average.	Average value per capita.
1830	$82,900,615	$8,290,062	$0.75	1870	$330,465,214	$33,046,521	$0.94
1840	139,507,716	13,950,772	.94	1880	395,376,936	39,537,694	.90
1850	130,058,518	13,005,852	.65	1890	433,459,813	43,345,981	.77
1860	313,332,730	31,333,273	1.16	1900	320,134,071	32,013,407	.46

The magnitude of our woolen industry may not be appreciated fully. It has suffered from adverse legislation, but is now producing more than ever before. This is one of four great manufacturing countries, and every one of the four has built up its wool manufacturing industry by protective legislation. Great Britain alone has abandoned this policy. France stands at the head in importance of manufacture. Great Britain comes next, and Germany and the United States are

nearly equal. It will not be long, doubtless, in the absence of adverse legislation, before this country will surpass all others in the extent and value of manufactures of wool. It has one advantage possessed by none of its rivals—a domestic supply of two-thirds of the mill consumption and pastoral areas sufficient for the whole of it.

Other countries must depend mainly on foreign wool, as France Great Britain, and Germany together only produce about as much as this country. This foreign dependence is thus indicated:

Imports and exports of wool by France, Great Britain, and Germany for 1890 and 1899

Countries.	Year.	Imports.	Exports.	Net imports.
		Pounds.	*Pounds.*	*Pounds.*
France	1890	371,722,377	39,575,579	332,146,798
	1899	558,456,820	64,993,961	493,461,859
Great Britain	1890	629,236,219	360,006,616	269,229,603
	1899	735,627,420	410,929,012	324,698,408
Germany	1890	283,542,424	19,872,264	263,670,160
	1899	391,636,633	19,920,064	371,716,569

France in 1890 had a domestic product of 124,803,000 pounds, which has greatly declined. Great Britain had 147,475,000 at that time, and Germany 54,894,000. The numbers of sheep in Germany and France have fallen off, increasing their dependence on imports of wool.

For the past ten years the wool supply of this country, domestic and foreign, has been about 430,000,000 pounds annually, which is about the same as that of Germany now, and nearly as large as that of Great Britain, exclusive of the stocks of shoddy and wastes of all kinds. About three-fourths of all the wool of the world is manufactured in these four countries, besides the remanufacture of the renovated rags of the world, of which the people of this country would be glad to accord Europe the monopoly, and with it the doubtful reputation of having the cheapest clothing.

The question has been repeatedly asked, Can we produce all the wools required for domestic manufacture? There is no doubt of the capacity of the country to produce more wool than is now consumed in any form. There are economic reasons that will doubtless prevent the production of very low-grade wools. Yet with 100,000,000 sheep there will be a considerable number of common sheep, such as Mexicans in the early stages of improvement; also the belly, neck, and breech wools of the coarse-wooled breeds will furnish a large quantity of carpet wool; and if these are not sufficient, woolgrowers will probably not object to the admission from abroad, at the present low rate of duty, of all that is necessary to meet the deficiency. But the clothing and worsted wools required can be and should be produced in sufficent quantity to meet the requirements of increasing population for many years to come. When our population is far more dense than at present, and the very limited exportation of woolen manufactures has

acquired a far greater volume, it will be time enough to begin to question the possibility of a full domestic wool supply.

The sheep is a factor in keeping up the fertility of lands. A million farms east of the Mississippi need them in their pastures to keep down growths of plants that cattle or horses do not touch. They are kept on lands in England far more valuable than the best in New York or Ohio.

Increasing population will require more meat. Years ago, when sheep were kept almost exclusively for wool, and the aged slaughtered for market in poor condition, tough and tasteless, "sheep meat" was not popular. Those days are past; mutton is appreciated and lamb is a delicacy that brings high prices. Mutton eating is rapidly increasing. It is taking the place of pork as a more palatable and healthful meat, and even reducing the relative consumption of beef, as in England.

It should be remembered that Ohio has had three times as many sheep as at present, and could easily care for 7,000,000 again; that the central West has had twice as many as now, with abundant lands for their pasturage, and for more than were ever before kept. Texas has kept three times as many as at the present time, and with increase of feeding resources, in forage plants, oil meal, and corn, in feeding supplementary to pasturage, can keep larger stocks than ever. The increase of beet-sugar factories, to be greatly accelerated in the future, furnishes material for feeding sheep in large quantities. Mutton production in the South, an industry feebly existent hitherto, can be made one of the most profitable in the agriculture of that section.

It is not easy to limit or measure the sheep-carrying capacity of the country, of the farms as well as the ranges. Little more than a third of the land is in farms, and, of many of the farms, not a third of the area is in cultivation or full occupation.

Maine, the "down-east" State of the Atlantic coast, has only a third of its area in farms, and its forest lands are among the most fertile in the East. The States east of the Mississippi can carry, without encroachment on other lines of rural industry, more sheep than there are now in the entire country.

Will this development be made? It depends entirely on economic conditions. If good prices of wool are maintained for a period sufficiently long to give the grower confidence, if practical education in feeding is advanced, and the promise of a permanently profitable business is assured, there is likely to be a realization of such an increase of flocks.

How many sheep would be required? Estimates have heretofore been considerably exaggerated. Sometimes it has been stated that 9 pounds per capita of wool are annually required in goods of all kinds. The consumption has never been so great. Eight pounds is

an ample estimate. The annual wool supply for the last ten years has averaged 444,514,274 pounds. The annual imports of manufactures of wool are valued at $32,013,407, against an annual average of $43,345,981 for the ten years ended with 1890. And these figures include, besides wool and manufactures of wool, a large proportion of shoddy and shoddy goods. Compare the fleece wools used in Great Britain with the quantity or value of manufactured goods, and an analysis will show how large a proportion of shoddy, flocks, mungo, and wastes of all kinds enter into the composition of this mass of manufacture. American shoddy itself makes an appreciable addition to the wools of the country, and always will, and they should be included in reckoning the wool requirements of our manufacture, appreciably reducing the amount required. In these high estimates of requirement every form of shoddy and waste, cotton and linen, that enters into the goods imported as woolens is counted as wool. It may be wool to the manufacturer, but it is not to the woolgrower.

A total of 60,000,000 sheep, producing 360,000,000 pounds of fleece and 60,000,000 pounds of butchers' wool, would have furnished very close to the supply for manufacture during the last ten years, without considering shoddy or substitutes. Should we reach a total of 80,000,000 sheep in a decade or two, a volume of 550,000,000 pounds of wool would be produced—more real wool than any nation in the world, except possibly France, has ever manufactured in a single year. When we reach 100,000,000, if we should, with 700,000,000 pounds of wool, fleece and pulled, with the substitutes that must be counted in manufacture, there would be a liberal and ample supply for a population of 100,000,000. This does not make allowance for a considerable quantity of carpet wools that are quite certain to be imported, and any other imports that manufacturers might fancy in their quest for novelties or preferences in wools, which must always reduce domestic requirements.

The present duties are not prohibitory. They will admit a large quantity of the third class, and more or less of the other two, no matter how large the domestic supply, but they will suffice to prevent an avalanche, maintain fair prices, and admit of gradual enlargement of wool production.

The fleece of the Angora goat, known as mohair, is one of the elements, however small, included with our foreign wool supply, and should be reckoned with the domestic. A few words regarding the Angora goat industry in this country are in order here. In 1849 Dr. Davis imported two bucks and six does of good quality. Colonel Peters followed with several importations. Diehl & Brown, in 1869, imported 135 animals; Mr. Israel Diehl had a commission from the Department of Agriculture to facilitate his work of selection. Maurice Brothers, of Texas, made importations in 1869, 1871, 1872, and 1873. Mr. John L. Harris went from California, in 1875, to Asia Minor to

investigate Angora breeding, and in California, Oregon, and Nevada has been engaged in breeding ever since, establishing large flocks and distributing to other States.

They are not confined to range districts, but have been held in many of the farming States from the Missouri to the seaboard. Recently there has been an active demand for them at advanced prices. In the agricultural exhibit of the Paris Commission there are 24 samples of mohair from a few of the prominent flocks, most of them collected by William R. Payne & Co., New York dealers in mohair and wools. They estimate the annual product of mohair at about 700,000 pounds, grown mostly in Texas, California, Oregon, and Nevada, and the number of goats at about 240,000.

THE CLASSIFICATION AND HANDLING OF AMERICAN WOOLS.

Early in the spring of each year, at the shearing of the annual clip, the principal woolgrowing sections swarm with buyers representing woolen mills and dealers in wools. Many of these are residents of the country, buying on commission, sometimes on speculation on their own account. All the conditions and influences tending to lower prices are of course urged to depress values at this time; and if the tendencies are sharply toward a higher level, as in the spring of 1899, the buyers are careful not to give them publicity. Yet intelligent growers are alert to ascertain promptly and accurately the drift of prices. Others are sometimes caught napping and part with their wool at prices which leave too large a margin to the speculative middleman.

The merino wools, or clothing wools, are commonly classified as Picklock, XXX, XX, X, one-half blood, three-eighths blood, and one-fourth blood, according to quantity and fineness. Picklock is an extremely fine fiber, of which a very little is found in the remaining Saxony flocks of breeders in western Pennsylvania. Most of these breeders have modified their flocks to obtain heavier fleeces of longer fiber, bringing much more money. There is also very little of the XXX grade, which is only exceeded in fineness by the purest breeding of Saxony Merinos. The mass of high-grade clothing wools is of the XX and X grades. The lower grades are made by dealers according to fineness and quality, without a knowledge (which would be impossible to attain) of the precise fraction of Merino blood of the sheep producing them.

The combing wools are of two classes. Formerly they were exclusively of the English mutton breeds, or at least were not of Merino origin. The exigencies of wool manufacture, the insufficiency of supply of true combing wool, made it necessary to adapt machinery for combing the merino carding or felting wools. This rendered necessary a fiber longer than 2½ inches, which is about the length of the finer qualities. A considerable difference always existed in length of fiber

of different families under different climatic and nutritive conditions; it was easy, by selection and breeding, to increase the length, a process of modification which has been in progress for many years. This merino division of combing wools is classified in three grades—fine, the finest of long staple; medium, not quite so fine; and low, of combing length and a little finer than the combing wool of mutton breeds. These are classed as three-eighths blood, one-fourth blood, common, and braid, the last being the long and lustrous wools of the Lincolns, and also of Leicesters and Cotswolds.

The condition of wool is an important element of value and of profit in sheep husbandry. It is a matter that demands the attention of growers, who could readily obtain a few million dollars more for the annual clip, mostly additional profit, by greater care in management and better methods of handling.

Neglect of flocks in winter, insufficient supply of feed, the great difference between the succulent spring pasture and dry winter feed, perhaps scarcely more liberal than the run of straw stacks, will cause uneven quality, reduction of strength, and decrease in price. Lands allowed to be overrun with weeds will fill fleeces with seeds and burs, and what is saved in labor is doubly lost in lower price. A great deal of dust and chaff in fleeces can be obviated by a little attention to methods of feeding. Care in shearing is also important, resulting in saving of wool and in better condition of the fleece.

In the putting up of wool for market there has long been a cause of variance and friction between grower and buyer in all parts of the country. The buyer complains of filthy tags and dirt in the fleeces, and of the use of unnecessary quantities of unreasonably large twine of a quality that injures the fabric in the manufacture. On the other hand growers say that when they exercise the greatest care in all these respects the buyers will allow no discrimination in price. There is doubtless some truth in these countercharges, yet a lot of fleeces carefully handled, of even quality, would claim some consideration from a practical buyer, or they could be sent to a reliable commission house and command a price that would pay well for the extra care. There is evidently room for much improvement on the part of seller and buyer, and the subject is worthy of the thoughtful consideration of both.

The advisability of washing sheep before shearing has long been a subject for discussion. Its purpose is the better condition and higher price of the wool. The difficulty presented, which appears to be insuperable, is in obtaining a uniform condition of cleanness. Necessarily some flocks have more foreign matter in their fleeces than others; there is always great difference in the amount of yolk or grease which the ordinary washing does not affect. Facilities for washing are very poor on many farms and ranges, and different methods of washing are

very unequal in their results. If a grower is not inclined to be exactly square in his dealings, or if his perceptions of strict honesty are a little confused by the unfairness of buyers in making no discrimination as to degrees of cleanness in buying, he may slight the process or drive the flock through muddy water. As a rule the grower evidently intends to be honest, but in the warfare of trade, where Greek meets Greek in a contest for self-preservation, ethical views are apt to become confused. With all these obstacles, it seems to be impossible to assure any great degree of uniformity in the cleansing of fleeces by farm washing. Then it is desirable to shear early, to give the flock a better chance for comfort and growth in the warmth of later spring, and also to obtain an opportunity of choice of time in selling, prices often being better in the early spring; but very early shearing involves a risk of injury from exposure. Altogether, most flock raisers prefer not to wash, and nearly all dealers unite in a preference for unwashed wools. They find so much unevenness that, in buying washed wool, they usually make some deduction from established washed rates, and in some cases pay little more than for unwashed. It is said that much of the country washing is a positive disadvantage in scouring the wool. Therefore the practice of washing is declining; in many districts it has been almost abandoned. The practice is in vogue in Michigan only to a limited extent, 9,696,446 pounds being unwashed of 12,025,802 pounds purchased by dealers last year, as reported by Prof. Herbert W. Mumford, in Bulletin No. 178 of the Michigan State Agricultural College, a very thorough inquiry into the reasons why Michigan wools sell at a lower price than those of Ohio and Pennsylvania.

In some parts of the country where climatic causes interfere to prevent evenness of fiber, as in Texas, New Mexico, Arizona, and southern California, the practice of shearing twice annually is adopted, the winter fleece being stronger and of greater value than the brash fiber grown in summer. It is a saving of wool and a great saving in annual proceeds of flocks. The summer and winter growth do not work well together, reducing both qualities to a low level.

The use of sheep-shearing machines is increasing. They shear closer, secure more wool than hand shearing, leave the fleece in evener condition, and are not so liable to cut the skin of the sheep. Yet their use is confined mainly to large flocks beyond the Missouri River. Small flocks do not warrant the expense of these machines and the trouble of keeping their knives in order, which are returned to the factory to be sharpened.

Unquestionably it will be in the interest of the grower to reform the awkward and unseemly methods of tying up for market, avoiding unseemly packages, the use of heavy twine of unnecessary quantity, and the inclusion of tags and other rubbish. These defects are so easily seen and so repulsive in the sight of the buyer that they must

influence his offer. There is great objection to using hemp twine, which injures the fabric with which it is mixed, and anyone who has attempted to free a fleece of the interminable tangle of much of the elaborate tying in vogue will acknowledge the task a practical impossibility. A small linen twine is recommended, and as it costs nearly as much per pound as the wool, there is no inducement to use a large quantity, and little will be required, once around the fleece each way being ample for a light fleece, and twice for a heavy merino fleece.

Neatness and honesty in putting up all products for market are yearly becoming more important in wool, cotton, fruits, everything. In the long run they will materially increase the profit of the production. It will not pay to sacrifice the profit of production by awkward and distasteful packing. There are millions of dollars in this practical idea.

An avoidance of these knotty and troublesome causes of difference between seller and buyer may be secured by making general the scouring of wool. Now that prices are fixed as nearly as possible on a scoured basis, the advantage to the grower is all the greater. There are many of these scouring-mill plants, even as far west as New Mexico, and one heavy flock master says he saved $1,668 on his clip by scouring. The saving of the freight on the grease and dirt is alone a large item.

THE COURSE OF PRICES.

The wool prices in the table following are for fine, medium, and coarse wools during a period of seventy years. They show frequent and sometimes sharp fluctuations, due to the influence of relative supply and demand, speculative operations in home and foreign markets, tariff changes, and other causes. Influences affecting prices are always operative, and analysis of their proportionate effect would require a volume. All that is deemed necessary here is to show what marked and more or less permanent changes in value have occurred.

One noticeable point is the cheapening of wool during the century. Near its beginning, in the period of war with Great Britain, the extreme quotation for the finest wool reached $2.50 per pound, but even then the lower grades were only a third as much. In 1824, when this record commences, the range of values by grades was from 68 to 40 cents, and higher values were reported in 1831, 1834, and 1837, with fluctuations down to 33 cents for fine in 1849. Later the requirements of the civil war period and the currency inflation made quotations higher, touching $1.02 for fine in 1865, when gold premiums were very high. In 1868, the time of sharp reaction in everything relating to wool, there was a fall to 48, and to 47 in 1871. When the flurry was over, in 1872, fine wool was up to 70 cents again. Then followed a long period of growth in the industries of woolgrowing and manufacture in this and all other woolgrowing countries. A gradual decline in the price of fine wool followed year by year, till

the price of 34 cents was reached in that ever-to-be-remembered year of culminating depression in prices, 1879, reacting to 50 cents in the following year, to decline gradually to 29 cents in 1893.

But this decline in fine wool does not give an accurate view of the fall in wool prices in the course of seventy years. While more than half was taken from the value of fine wool, medium fell from 53 to 33 cents, and coarse only from 40 to 29. It will be observed that these two grades in the beginning were 68 and 40, at the end 29 and 29. Fashion in fabrics ran to coarse weaves, to worsteds rather than to smooth cloths.

A reference to the table will show in several instances very marked fluctuations in price between January and July of the same year, as in 1824, fine falling from 68 to 55, and in 1831 rising from 70 to 75, and in 1836 again from 65 to 70 cents. In coarse wool in 1893, between January and July, there was a fall from 29 to 25, as in a similiar period in 1824 it fell from 40 to 30 cents, and in 1827 from 28 to 25 cents. At several dates in seventy years did coarse wool touch 25 cents, and in 1849 a lower figure, 23 cents. It can not be said that the record of prices of coarse wool has been marked by any serious or permanent decline.

Wool prices of seventy years, 1824–1893.

[Mauger & Avery's annual wool circular.]

Year.	January.			July.			Year.	January.			July.		
	Fine.	Medium.	Coarse.	Fine.	Medium.	Coarse.		Fine.	Medium.	Coarse.	Fine.	Medium.	Coarse.
	Cts.	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*		*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*
1824	68	53	40	55	40	30	1859	60	52	45	56	40	35
1825	60	43	32	50	41	32	1860	60	50	42	55	50	40
1826	55	43	38	37	30	26	1861	45	40	37	38	30	22
1827	36	32	28	37	31	25	1862	48	50	50	48	47	45
1828	42	30	25	48	38	33	1863	75	68	70	75	70	65
1829	54	45	35	46	36	32	1864	80	78	76	1.00	1.00	90
1830	40	35	30	60	50	40	1865	1.02	1.00	96	75	73	65
1831	70	60	48	75	65	50	1866	70	65	50	70	67	60
1832	65	55	44	50	42	30	1867	68	53	50	55	49	45
1833	55	41	33	61	54	40	1868	48	43	38	46	45	43
1834	70	60	48	60	50	40	1869	50	50	48	48	48	47
1835	63	50	40	63	56	42	1870	48	46	44	46	45	43
1836	65	60	45	70	60	50	1871	47	46	43	62	60	55
1837	72	63	48	52	52	36	1872	70	72	66	72	70	65
1838	50	42	35	46	36	30	1873	70	68	65	50	48	44
1839	56	48	38	57	48	40	1874	58	54	47	53	53	46
1840	50	45	38	45	39	33	1875	55	56	47	52	49	46
1841	52	45	35	50	44	34	1876	48	52	42	38	35	31
1842	48	42	35	43	37	30	1877	46	43	36	50	44	37
1843	35	30	25	35	30	26	1878	44	45	38	36	36	32
1844	37	30	26	45	37	32	1879	34	35	32	37	38	34
1845	47	40	31	40	36	30	1880	50	55	48	46	48	42
1846	40	35	30	38	32	27	1881	47	49	43	42	44	36
1847	45	40	30	46	40	31	1882	44	46	47	42	45	34
1848	45	38	30	38	32	28	1883	40	43	33	39	41	33
1849	33	30	23	40	35	28	1884	40	40	34	35	34	30
1850	47	40	33	45	37	30	1885	34	33	29	32	31	28
1851	46	40	33	47	42	37	1886	35	36	32	33	33	29
1852	43	38	34	45	38	33	1887	33	38	34	34	37	34
1853	58	56	50	60	53	48	1888	31	35	33	29	33	31
1854	53	47	42	45	37	30	1889	34	38	33	35	39	32
1855	40	35	32	50	40	33	1890	33	37	29	33	37	29
1856	50	38	35	55	42	36	1891	33	37	31	31	35	29
1857	56	50	42	56	50	40	1892	30	35	31	28	34	30
1858	40	33	27	43	37	30	1893	29	33	29	24	26	25

Philadelphia wool prices, 1885–1892.

[Circular of Coates Brothers.]

Kinds of Wool.	1885.	1886.	1887.	1888.	1889.	1890.	1891.	1892.
OHIO, PENNSYLVANIA, AND WEST VIRGINIA WASHED.	*Cents.*	*Cents.*	*Cents.*	*Cents.*	*Cents*	*Cents.*	*Cents.*	*Cents.*
XX and above	32–35	34–35	34–36	29–31	34–37	33–35	31–33	28–30
X	30–31	31–33	32–34	28–29	33–34	31–33	29–31	27–28
Medium	30–31	34–35	38–40	32–35	38–40	37–39	36–37	33–35
Quarter blood	28–29	33–34	38–39	31–34	37–38	36–37	34–35	33–34
Common and cotted	22–25	27–30	30–35	28–30	30–33	28–30	28–31	28–31
NEW YORK, MICHIGAN, AND INDIANA WASHED.								
XX	28–29	31–33	31–33	27–29	32–34	30–32	29–30	27–28
X	27–28	30–31	30–32	25–27	31–32	29–30	27–29	25–27
Medium	30–30	33–35	37–40	31–34	37–39	36–38	35–36	33–34
Quarter blood	27–28	32–33	37–39	30–33	36–37	35–36	33–35	32–33
Common and cotted	22–23	27–29	30–35	28–30	30–33	28–30	28–30	28–30
COMBING AND DELAINE FLEECE.								
Washed fine delaine	33–35	33–35	36–38	31–33	36–38	35–37	34–36	31–33
Washed medium	32–35	35–36	38–40	34–36	38–41	38–41	38–39	35–37
Washed low	30–31	34–36	37–39	32–35	37–38	36–38	35–37	34–35
Washed coarse	27–29	32–34	35–37	30–33	33–36	32–33	32–35	30–33
Unwashed, medium	24–26	27–28	32–35	25–28	30–33	30–32	30–31	26–28
Unwashed, low and coarse	21–24	25–27	30–32	23–25	27–29	25–27	25–27	26–27
LIGHT AND BRIGHT, UNWASHED.								
Fine	20–21	21–22	22–25	17–20	23–25	20–23	19–21	18–20
Medium	22–24	27–28	30–34	24–27	29–32	27–30	26–29	25–27
Low medium	20–22	25–26	28–30	23–25	28–29	25–27	24–26	24–26
Coarse	15–17	20–22	22–25	20–23	22–25	20–23	18–22	18–22
DARK COLORED, UNWASHED.								
Light fine	17–20	19–21	19–22	15–17	20–22	17–20	16–18	16–18
Heavy fine	.....	.....	19–22	12–14	16–19	14–16	14–16	14–15
Medium	18–20	22–25	25–28	16–20	23–26	22–24	20–22	19–22
Fine medium	16–18	22–23	.....	15–17	20–23	18–22	17–19	16–18
Coarse	15–16	17–19	22–24	15–16	18–22	16–18	18–20	17–20
COLORADO, UNWASHED.								
Medium and fine, choice	17–20	23–26	25–28	20–23	24–27	22–25	22–24	21–23
Medium and fine, heavy	17–18	21–23	22–24	18–20	18–22	16–20	15–18	15–17
Common and quarter blood	16–17	20–21	20–22	16–18	19–22	18–20	18–20	17–19
Coarse, carpet	15–16	17–18	17–18	14–16	17–18	16–17	16–17	16–17
NEW MEXICAN, UNWASHED.								
Choice improved	16–20	22–25	23–26	19–22	24–26	22–24	20–22	21–22
Partly improved	15–16	19–21	21–23	16–18	21–23	19–21	18–20	17–19
Coarse, carpet, light	14–15	17–18	16–18	14–16	17–18	16–17	16–17	15–16
Coarse, carpet, heavy	13–14	15–17	15–16	13–14	15–17	14–16	14–16	13–15
Black	12–13	15–16	15–16	12–15	16–18	15–17	14–16	12–15
TEXAS, UNWASHED.								
Fine, 12 months	18–22	21–24	20–23	16–18	20–24	20–22	20–22	18–20
Medium, 12 months	20–25	25–27	25–28	18–24	24–28	24–26	23–24	20–24
Coarse, 12 months	14–15	17–18	18–20	14–15	18–22	18–20	17–19	17–19
MONTANA, UNWASHED.								
Fine bright	20–22	20–23	21–23	16–18	20–24	20–22	17–21	17–20
Medium bright	20–22	24–27	26–28	18–22	24–28	24–26	21–24	20–24
Coarse bright	16–18	20–23	20–23	16–18	20–22	18–20	18–20	17–20
Dark colored, heavy	16–18	18–20	18–20	14–16	17–22	16–20	16–20	15–18
UTAH AND WYOMING, UNWASHED.								
Light fine	18–19	20–22	20–23	14–16	19–22	18–20	17–20	17–20
Heavy fine	16–17	18–20	18–20	12–14	16–19	14–16	14–16	14–16
Fine medium	17–18	21–23	22–24	15–17	20–24	18–21	18–21	18–20
Selected medium	19–20	24–26	26–28	18–22	24–27	21–24	22–24	22–24
Low	15–16	17–19	22–24	16–18	20–22	19–21	18–21	18–20

Philadelphia wool prices, 1885–1892—Continued.

[Circular of Coates Brothers.]

Kinds of wool.	1893.	1894.	1895.	1896.	1897.	1898.	1899.	1900.
OHIO, PENNSYLVANIA, AND WEST VIRGINIA, WASHED.								
	Cents.	*Cents.*	*Cents.*	*Cents.*	*Cents.*	*Cents.*	*Cents.*	*Cents.*
XX and above	25–26	20–21	17–19	17–19	21–23	28–30	28–30	28–30
X	24–25	18–20	16–17	16–17	20–21	26–28	26–28	27–28
Medium	27–28	20–22	19–20	18–19	22–23	28–30	29–30	30–32
Quarter blood	26–27	20–23	21–22	18–19	22–23	28–30	28–30	30–32
Common	24–25	18–19	18–19	17–18	20–22	24–25	25–27	27–28
NEW YORK, MICHIGAN, AND INDIANA, WASHED.								
XX	23–25	18–20	16–17	16–17	19–20	25–26	23–25	24–25
X	22–23	16–18	15–16	15–16	18–19	23–25	22–23	23–24
Medium	27–27	20–21	18–20	17–19	21–22	27–29	28–30	30–31
Quarter blood	25–26	20–22	20–22	17–19	21–22	27–29	28–29	30–31
Common	24–25	18–19	17–18	16–18	20–21	23–25	25–26	27–28
COMBING AND DELAINE FLEECE.								
Washed fine delaine	25–27	20–22	18–20	18–20	22–23	29–30	30–32	30–32
Washed medium	28–30	21–23	20–22	19–20	23–24	29–30	30–31	31–33
Washed low	27–28	22–23	22–23	19–20	23–24	28–30	29–30	31–33
Washed coarse	25–26	20–21	19–20	18–19	22–23	25–27	26–28	28–30
Unwashed medium	21–23	17–18	16–18	15–16	18–19	22–23	23–24	24–25
Unwashed quarter blood	20–21	17–19	17–19	15–16	19–20	22–23	22–24	24–25
Unwashed braid	18–20	16–17	16–17	14–15	18–19	20–21	20–21	20–21
LIGHT AND BRIGHT, UNWASHED.								
Fine	15–18	10–13	11–13	10–12	13–15	18–20	17–20	17–19
Medium	20–22	14–16	15–17	14–15	17–18	21–23	22–23	23–24
Quarter blood	19–20	15–17	16–18	14–15	18–19	21–22	21–23	23–24
Coarse	17–18	14–16	15–16	13–14	17–18	19–20	19–20	17–20
DARK COLORED, UNWASHED.								
Light fine	13–15	8–10	9–10	8–10	11–12	14–15	14–16	15–17
Heavy fine	11–12	6– 8	6– 8	6– 8	10–11	12–13	12–15	.....
Medium	16–18	11–13	12–13	11–13	13–15	17–18	17–19	20–22
Fine medium	14–16	10–12	10–12	10–12	13–14	14–16	15–17	16–20
Coarse	14–17	11–12	11–12	11–13	13–15	14–15	15–16	16–18
COLORADO, UNWASHED.								
Medium and fine, choice	16–19	11–13	11–13	11–13	12–15	15–16	16–17	16–20
Medium and fine, heavy	12–14	7–10	8–10	8–10	9–11	12–13	12–13	12–14
Common	14–16	12–13	10–12	10–12	12–15	14–15	13–15	15–16
Coarse, carpet	13–14	11–12	10–11	10–11	10–13	12–13	12–13	14–15
NEW MEXICAN, UNWASHED.								
Choice improved, light	15–18	12–13	12–13	11–13	13–15	15–16	16–17	16–19
Partly improved, light	14–15	11–12	11–12	10–12	12–14	14–16	14–15	15–17
Coarse, carpet, light	12–13	10–12	9–10	10–11	11–13	12–13	12–13	14–15
Coarse, carpet, heavy	11–12	8–10	8– 9	7– 9	9–11	10–12	10–12	12–14
Black	10–12	9–10	8–10	7– 9	10–12	12–13	12–13	13–15
TEXAS, UNWASHED.								
Fine, 12 months	15–17	10–12	10–12	9–11	11–13	12–13	13–15	15–17
Medium, 12 months	17–20	11–13	12–14	11–12	13–15	14–15	15–17	15–20
Coarse, 12 months	13–15	10–11	10–12	10–11	11–13	13–14	14–15	14–16
MONTANA AND DAKOTA, UNWASHED.								
Fine bright	14–16	8–10	9–11	8–10	11–13	12–13	12–14	16–18
Medium bright	17–20	10–12	11–14	10–12	13–15	15–16	17–18	18–20
Coarse bright	15–17	10–12	11–13	9–10	12–14	14–15	15–16	16–18
Dark colored, heavy	12–14	6– 8	8–10	6– 8	9–11	11–13	11–13	14–16
UTAH AND WYOMING, UNWASHED.								
Light fine	12–14	7– 9	9–10	8–10	11–12	12–13	14–15	16–17
Heavy fine	10–12	6– 8	8– 9	6– 8	9–10	10–11	12–13	14–15
Fine medium	14–15	8–10	10–12	9–11	12–14	14–15	15–17	17–20
Selected medium	16–18	10–12	12–14	11–13	13–15	16–17	17–18	20–21
Low	14–16	10–12	10–12	9–10	12–13	13–14	14–15	16–18

The decline in the wholesale price of Texas medium from 24–26 in 1890 to 11–12 in 1896 was a discouraging fall, but the drop in farm prices of this highest quality of Texas wool from 23 to 9 cents was ruinous. The farm prices of the lowest grades, not given in this table, were scarcely half as much.

The Montana wools, at the lowest point, are quoted in the lower grades at 6–8 cents, and the new Mexican at 7–9. These figures meant 4 to 5 cents to the growers.

In these quotations Ohio medium is recorded at 38–40 cents in 1887 and 1889, with somewhat lower prices in other years, feeling the competition with Australian skirted wools after 1890, and quoted in 1892 at 33–35. Then, owing, doubtless, to the expectation of free wool, the price fell to 27–28 in 1893, 20–22 in 1894, 19–20 in 1895, and 18–19 in 1896. In 1897 it rose to 22–23, in 1898 to 28–30, in 1899 to 29–30, reaching the highest point of recovery in January, 1900—35–38 cents. It required three years to clear away the accumulation of foreign wool.

Prices recently have been temporarily depressed by the slow sales and low prices in London, in consequence of accumulations of stocks drawn from all parts of the world by the high prices of last autumn and winter. There is great activity in manufacture in all manufacturing countries, and while the production of wool is increasing, there is an admitted scarcity of fine wools, which must tell favorably on future prices.

PERIODS OF DECLINE AND REVIVAL.

Sheep husbandry is an industry peculiarly sensitive to influences either adverse or favorable. Early in the present century, when importations of the Spanish Merino elicited general interest, and in the period of the war of 1812, when clothing supplies were dependent on domestic manufactures, speculation was rife and prices were high, record being made up to $1,000 for a single individual for breeding purposes. Woolgrowing became a craze in New York, Massachusetts, and Vermont, and excited much attention in other States as far south as Maryland and Virginia.

The manufactures of those days were mostly domestic or household products. England furnished nearly all of the supplies that were not homespun. At the beginning of the war of 1812 duties were necessarily raised. The effect was a prompt and potent stimulus to home manufactures. But in 1816, after the war, duties were reduced without foreseeing the disastrous results which followed. The market was soon overburdened with foreign goods, prices fell heavily, and the manufacture of wool nearly ceased. It was at this time that Lord Brougham is reported as saying that "it is well worth while to incur a loss upon the first importations, in order by the glut to stifle in the

cradle those rising manufactures in the United States which the war has forced into existence contrary to the natural course of things."

For eight years there was little progress in manufacture and small encouragement to woolgrowing. Sheep were few and neglected. Business was paralyzed, distress general and severe. Under the tariff of 1816 not only was wool manufacture stranded, but earthenware making disappeared, glass factories were blown out, and iron manufacture diminished yearly. Losses greater than those of the war were impoverishing the country. Henry Clay referred to this period as the time of the most widespread dismay and desolation since the adoption of the Constitution.

After the tariff of 1824 woolgrowing and its manufacture revived, sheep increased, and in 1830 a promising start had been made and the value of manufactured goods was $14,528,166. During this decade only 8,000,000 pounds of foreign, added to the domestic, wool was manufactured annually. The wool manufacture continued to increase until 1833, the woolgrowers prospered, and the gloom and distress of the former period were followed by industrial activity and great prosperity.

Then came another period of discouragement to woolgrowers. The compromise act of 1833 provided for a gradual reduction of duties till 1842, to be succeeded by a uniform duty of 20 per cent. In four years of decline, intensified each year, wool manufacture was again prostrated, and with it the industries of the country, in a financial panic the severest in some respects ever known in the history of the country.

When 1842 came in, instead of the proposed moderate revenue duty, a protective enactment insured a new era of prosperity to both branches of the wool interest, to be again prostrated by a reduction in 1846, which caused the closing of many factories within the next two years and further discouragement to woolgrowing. In the years following, a period of stirring events, the finding of gold in California, the great development of gold and silver mining, the Crimean war, the growing demand for cotton throughout the world, were boom elements, causing activity and growth in many lines; yet wool manufacture languished, growing feebly with the demands of a rapidly increasing population, till the enactment of the Morrill tariff in 1861 and the era of enormous war demand, which in four years doubled the manufacture, increasing the wool consumption in factories from 80,000,000 to 160,000,000 pounds. Partial mill returns in 1864 made a total of 120,000,000 pounds, and further investigation gave a reasonable assurance of 40,000,000 more. For the four years there is a statistical showing of the Department of Agriculture of an average wool supply of 145,000,000 pounds per annum.

In eight years the number of sheep was almost and the amount of

wool fully doubled. This showed the marvelous possibilities of American woolgrowing under favorable circumstances.

It was a very remarkable exhibit of these possibilities that under the unusual exigencies of that period creating an extraordinary demand for woolens, which was greatly increased by the wastes of war, these demands were met by home manufacture with a smaller importation per capita than in the preceding decade of low prices and universal peace. Wool imports increased from 31,638,000 pounds in 1861 to 67,917,031 in 1865. The average price advanced from 13.7 cents in the former year to 17.6 in 1865, but fell in 1867 to 13.8, causing a marked increase in quantity imported. Flocks were enlarged as rapidly as possible, but the increase in wool was relatively larger than in sheep, resulting from the use of heavy wooled Merino sires in the flocks of Texas, New Mexico, California, and the Rocky Mountain range country.

In the war period new branches of textile fabrication were introduced or greatly extended, including the manufacture of fine worsted goods for ladies, new styles of fancy cassimeres, carpets, and other textiles, and the prices of some were actually cheapened by the home competition with what had been a foreign monopoly. Greater progress was made in respect to quality and variety of goods than for twenty years prior to 1860.

This period was one of remarkable development of woolgrowing and wool manufacture throughout the world. It was not alone the demand for goods caused by the civil war in this country, but the arrest of cotton growing and the blockade which hindered the shipment of the little that was grown, which caused a dearth of cotton, that alarmed the commercial world and stimulated the production of woolen goods to take the place of cotton. The increase in the average price of wool imports, 28 per cent in five years, indicates the sudden enlargement of woolen manufacture throughout the world. The exports of British manufactures of wool increased in these five years from £14,444,774 to £25,251,889, a total greater than that of the exports twenty years later. The wool imports of Great Britain nearly doubled in the same time. The industry in France, Germany, and other countries was similarly stimulated, and prices of the raw material and of the goods were similarly advanced.

After the close of the war, as cotton growing began to assume importance again, the boom in wool showed signs of decline. The wool supply, which had been so greatly enlarged in Australia, South Africa, South America, and North America, and even in Europe, was now in excess of the demand, and in 1865 the average price of our wool imports was reduced to the level of 1861. Abroad prices were falling in the expectation that cotton growing would promptly occupy its former position; in this country they were further reduced by the

decline of the gold premium. Our woolgrowers, who had been elated by the unaccustomed prosperity of the recent past, began to succumb to despondency, which affected first the flock owners east of the Missouri, inducing migration to the great ranges and a free movement to city markets. This discouragement gradually deepened until 1868, when panic seized the woolgrowers, and the slaughter of the flocks, especially the culls and lower grades, for the pelts and tallow, commenced in the great woolgrowing centers at improvised slaughtering and rendering establishments, which paid 75 cents to $1.50 each. The "hams" of the best were saved and salted for use as mutton. This destruction was more general in Ohio than elsewhere. In the principal woolgrowing counties the reductions were from 10,000 to 40,000; in Michigan and other States slaughtering was also active. The assessors' returns in Ohio in 1868 showed a reduction of 1,349,855, and in the two following years a loss of 1,969,736 more. The total decrease in Ohio in three years, from 7,622,495 to 4,309,904, was 43 per cent. The total reduction in the United States in 1868 was 4,500,000, according to published estimates of the Department of Agriculture.

The Department's review of the condition of farm animals in April, 1869, reflected the demoralization which had befallen the industry. It shows the great injury from neglect and disease which invariably results from discouragement at such a time of panic, as follows: "The wool business has been comparatively unprofitable of late, and the inevitable result is neglect, short commons, a supply of moldy hay, and the roughest treatment, in too many instances resulting in leanness, weakness, and insidious approaches of disease. Where they have been suitably cared for they are healthy, and as Merinos are in present disfavor, disease is mainly among flocks of that breed. Were it not for the cutting process by which millions of the poorest have been remorselessly slaughtered for their pelts and the small modicum of fat that could be drained by hydraulic pressure from their juiceless carcasses, the ravages of disease would have proved far greater."

One of the "last straws" that burdened the markets and helped to break them down was the sale by Q. M. Gen. M. C. Meigs, in the fiscal years 1866 to 1871, inclusive, of an immense surplus of military clothing. It included 2,218,917 overcoats, 802,419 blankets, 353,887 pantaloons, 359,253 sack coats, 427,729 jackets, 639,569 felt and other hats, 404,006 flannel and other shirts, 104,903 yards flannel, 152,951 yards kersey, 60,791 yards dark blue cloth, 216,380 pairs stockings, and other clothing material. There were overcoats alone enough to supply a third of all the voters in the country. This, in addition to the glut of commercial stocks of woolens, could not fail to produce a very disastrous result.

The estimates of sheep and wool, as stated approximately in round numbers in response to a resolution of the United States Senate, for

ten years commencing with the first enumeration after the commencement of the war, with the fleece wool, not including the pulled wool from sheep slaughtered which was considerable in the later years of this period, are as follows:

Estimated number of sheep and product of wool in the United States, 1862–1871.

Year.	Sheep.	Wool.	Year.	Sheep.	Wool.
		Pounds.			*Pounds.*
1862	24,000,000	67,000,000	1867	42,000,000	147,000,000
1863	28,000,000	82,000,000	1868	41,500,000	155,000,000
1864	31,000,000	95,000,000	1869	37,000,000	143,000,000
1865	35,000,000	115,000,000	1870	34,000,000	135,000,000
1866	38,000,000	135,000,000	1871	32,000,000	128,000,000

These figures cover the fluctuations of periods of prosperity and adversity in wool production which affected profoundly this industry in all parts of the world, and the causes had their origin mainly in conditions prevailing in this country.

TARIFF CHANGES AND THEIR EFFECTS.

It was during this period of depression, before its culmination, that the tariff of 1867 was enacted. The question has been asked, why it did not avert the disaster. The fact is that it was too late. The mischief had been already done. As early as 1865 the imports of manufactured wools, more than double the requirements of demand, began to glut the markets. Prices were falling throughout the world. But that enactment opened a new era of prosperity for woolgrowing, after the glut of goods had been absorbed, in which flocks increased 60 per cent in thirteen years and the wool product 100 per cent—the number of sheep, 50,626,626 in 1884, being larger than at any other time in the history of American woolgrowing.

In 1883 there was a slight change in the tariff, and in years following revenue decisions liberal to importers, which tended to discouragement of woolgrowers and a decrease of flocks, reducing the numbers in five years about eight millions, from 50,626,626 to 42,579,079. Values were highest in 1883, before the tariff enactment, $2.57, and lowest in January, 1886, but not increasing materially until the enactment of the McKinley law. The decrease in numbers was 16 per cent, and in price 24 per cent. An expectation of tariff revision prevented further sacrifice of flocks.

A new era of prosperity commenced in 1890. In four years the number of sheep increased to 47,851,000, or 11 per cent, from 1889, and the farm value advanced in January, 1893, to $2.66, the highest value for eighteen years, since 1875.

In 1894 was enacted a law making wool absolutely free, as well as all forms of shoddy and waste materials used in adulteration. The

effect was instantaneous. Prices of wool and of sheep declined, resulting in destruction of flocks and indifference and neglect in their care.

The law of 1897 followed, restoring customs duties on wool. The effect of this act has been to restore confidence in the future of woolgrowing and a larger degree of prosperity, though the enormous accumulation of foreign wool has retarded manufacture and sale until quite recently. For two years the mill stocks and wool markets were weighted down with foreign wool. Estimates of the trade authorities made the supply in January, 1900, 250,000,000 pounds less than in the preceding January. Consumption has been unprecedented and manufacture extremely active.

The value of sheep is nearly doubled. The Department estimate of average value in January, 1895, was $1.58 per head, and last January, $2.93. The increase in the price of wool is strikingly indicated by a diagram (fig. 1) prepared by Justice, Bateman & Co., showing the London value of American wool, with American prices of the same grade, and London value of similar Australian wool, from 1892 to 1900, the depression of the free-trade period, and the subsequent recovery under present law.

It appears that XX Ohio, which was worth 18 cents in London in 1897, when the Dingley bill was passed, rose to 23½ cents in the United States, though our markets were burdened with an enormous supply of foreign wool bought on a free-wool basis; and the next year, when a relief from this handicap had barely commenced, it was worth 29 cents here and 19½ cents in London. Since then there has been a great boom in foreign wool, which sent prices up temporarily, and in 1899 XX Ohio ran in London to 25½ cents and was 29½ cents here; but the collapse of the London boom has brought the price down to 22½, while it is here 31 cents, or 5 per cent above the average of last year. The London decline, both of XX Ohio and of scoured Botany Tops, is 12 per cent below the average of last year's prices.

The diagram shows in XX Ohio a comparatively slight fluctuation in London between 1892 and 1897, but in this country a fearful fall, 29½ to 17½ cents, where it remained with slight change for three fateful years, at the bottom of a depression which was a veritable slough of despond to the American woolgrower. The recovery under the present law, shown in a line almost vertical, is as sudden as the fall was precipitate.

The effect of the law of 1894 on manufacturers was scarcely less injurious than upon woolgrowers. They were not subjected to free goods, but were exposed to a competition under a reduced rate of duty, which they could not withstand, flooding the country, stopping sales, first exhausting profits, then reducing wages, and finally shutting down mills.

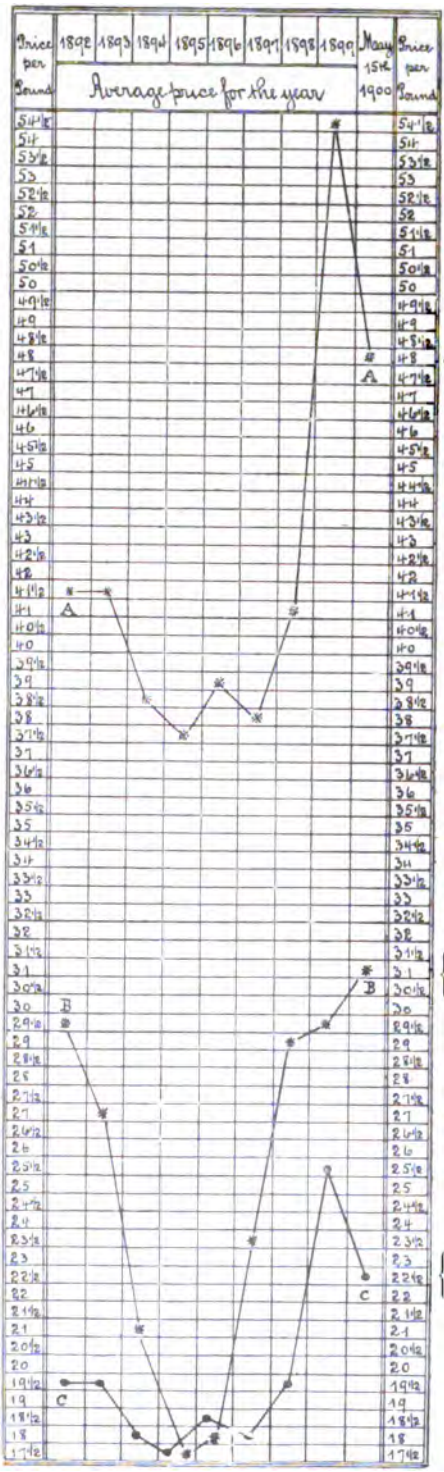

Fig. 1.—Diagram showing fluctuations in the price of wool, 1892-1900.

LINE A TO A represents London values of Merino wool scoured, carded, and combed into No. 60's Botany Tops, wool similar to XX Ohio. On May 15, 1900, the decline from the average of 1899 was 12 per cent.

LINE B TO B represents American prices for XX Ohio. On May 15, 1900, the advance from the average of 1899 was 5 per cent.

LINE C TO C represents London values of XX Ohio. On May 15 the price had fallen 12 per cent below the average of 1899.

Most of the manufacturers knew that free wool, under existing conditions, would prove inimical to their prosperity, though a few desired it. One of those, after a sad experience with the law of 1894, says:

> We as well as others thought this Wilson bill would be a godsend to all interested in the woolen line, but we have had the experience, and a good lesson it has been to us, and one that we are not likely to forget as long as we live.

Those who favored free wool and woolens have claimed that manufacturers, with the markets of the world in which to select their raw material, could make better goods, supply the country, export freely to other nations, and achieve a wonderful prosperity. Every one of these claims has been signally disproved by the experiences of 1894–1897.

It is no boast to say that there are no stronger or more serviceable wools in the world than those of the United States. They are wools of a temperate climate and of a progressive agriculture, and not from flocks of the torrid zones, neglected in breeding and care; they are from sheep bred toward the most approved types of clothing and combing wools. All the families of Merinos and all the improved English mutton breeds are represented. No European country has such a variety of wools as America, and none a superior average quality. Excepting Europe, the British colonies, and the Plata River region, all other countries grow wools distinctly and greatly inferior to ours. If we must depend on the wools of foreign countries we must be subject to competitive buying by England and other countries, under a serious handicap of trade and transportation advantages; must take what we can get; and a large portion must be the harsh and weak fiber of hot climates and that of neglected and poorly fed flocks—kempy, burry, and dirty. Is this a condition for securing better wool or better cloth?

Australian wools are popular, but their Merino blood came from Germany and America (Vermont and New York), and their Lincolnshire crosses furnish a lustrous article, very desirable for certain fabrics. The climate, with its torrid seasons of drought and destruction, is unfavorable for evenness and strength of fiber, and such wools are not equal in integrity and durability to our Merino.

While admitting the preference of fashion in certain fabrics, it is undeniable that the riddance of dirt and inferior portions of the fleece by skirting, and the smaller shrinkage resulting in part from this practice, gives most of the superior selling price of this wool in the markets. It is true that the manufacturer naturally likes unlimited range for selection, and truer still that price advantage—cheapness—is a factor of more controlling influence than any other in the selection and blending of material and fabric modification. Under the exigency

of scarcity and dearness, even a carding wool has been made a combing wool, requiring invention and adaptation of machinery to aid in the transposition, so that now a considerable portion of the worsted manufacture is from the Merino instead of the mutton breeds. In all the kaleidoscopic changes of style and admixture of material, it is by no means fashion that is the only or main consideration, but relative economy.

The law of 1894, instead of bettering the quality of the supply of woolens, degraded it to a condition never before existing, precipitating an era of shoddy. Mr. S. N. D. North, the secretary of the Wool Manufacturers' Association, testified before the Ways and Means Committee, in January, 1897:

> There has been more shoddy used in American goods in the year just passed than ever before, and more shoddy, mungo, and miscellaneous refuse contained in the goods imported in that year than have come into the United States in any previous twenty-five years.

And he said further, that nothing could be more certain, if conditions which introduced them should continue, than that the American manufacturer must meet them by the use of similar materials. He showed a piece of cloth, ingeniously fabricated to look like honest goods, in which there was not a particle of new wool, but which was made from the vilest of shoddy, and sold at a profit at less per yard than the market price of a pound of clean wool. In the testimony of one of the dealers in "woolen rags" it was admitted that some of this stuff was imported in a "condition decidedly offensive, and a great menace to the health of the community."

American shoddy from tailors' clippings and clean rags is a decent article compared with the lowest class of European material, known as mungo, which comes from cloth which may be first worn by a fastidious gentleman, who sells it to a secondhand dealer, to be next worn by a clerk or mechanic, then by a laborer, a tramp, or beggar, in its descent to the gutter, saturated with filth and germs of diseases and half rotten, thence to be resurrected, washed, treated with chemicals, and run through disintegrating machinery to appear as "mungo," selling at less than a cent per pound, and put into goods selling at a shilling per yard, and offered to American citizens as a boon to the poor man and a blessing to the clothing buyer of small means.

The figures of the United States Treasury record of imports are eloquent in portraying the inundation of foreign shoddy and shoddy goods, during the period covered by the law of 1894. The rags and various wastes imported under the two laws are thus compared:

Amount and value of woolen rags, shoddy, mungo, etc., imported into the United States, 1892–1900, by three-year periods.

Year ended June 30—	Law of 1890.		Law of 1894.		Law of 1897.	
	Amount.	Value.	Amount.	Value.	Amount.	Value.
	Pounds.		*Pounds.*		*Pounds.*	
1892	262,992	$87,825				
1893	333,376	106,596				
1894	143,002	47,522				
1895			14,066,054	$1,980,464		
1896			18,761,109	2,651,237		
1897			49,413,642	6,935,658		
1898					3,298,751	$697,622
1899					314,540	70,224
1900					435,854	86,887
Average	246,456	80,647	27,550,268	3,855,786	1,349,715	284,911

The law of 1894 went into effect August 1 of that year, so there were only eleven months of imports of the fiscal year ended June 30, 1895; and as the law of 1897 went into effect as to shoddy January 1, 1898, the record of 3,298,751 pounds of shoddy included nearly six months' imports under the law of 1894, nearly all of it.

The figures of the Treasury show an importation of shoddy of about 118,000,000 pounds in thirty years, nearly three-fourths of which, or about 85,000,000 pounds, was received in this period of a little more than three years. Thus an annual average of nearly twenty times as much was received in the free-shoddy period. In addition to the figures given above those of the two preceding decades should go into this record to facilitate comparison. As manufacturers reckon 1 pound of cloth equivalent to 4 pounds of wool in the grease, and 1 pound of shoddy or waste (cleaned with very small loss in manufacture) equivalent to 3 pounds of wool in the grease, it will be seen that this 85,000,000 pounds of shoddy took the place of 255,000,000 pounds of domestic wool, or nearly one year's product.

Amount and value of woolen rags, shoddy, mungo, waste, and flocks imported into the United States, 1871–1890.

Year ended June 30—	Amount.	Value.	Year ended June 30—	Amount.	Value.
	Pounds.			*Pounds.*	
1871	1,277,495	$87,667	1882	1,097,641	$358,386
1872	2,719,246	232,211	1883	974,963	438,750
1873	1,989,123	199,687	1884	1,316,083	564,694
1874	1,783,677	151,156	1885	700,231	287,254
1875	1,387,731	119,109	1886	3,059,214	1,036,869
1876	243,527	45,322	1887	4,834,636	1,843,823
1877	169,925	33,265	1888	4,483,325	1,719,154
1878	95,886	19,071	1889	8,662,209	3,417,201
1879	92,614	22,121	1890	4,980,327	2,052,078
1880	1,388,233	297,196			
1881	470,873	138,363	Total	30,579,502	11,886,572

The theory that dear wool compelled manufacturers to use shoddy and that free wool would obviate its use, has been forever destroyed in this

deluge of material for cloth adulteration. It was a surprise to the theorists, but it is thus explained in the bulletin of the wool manufacturers:

So long as our manufacturers did not have to compete with foreign shoddy-made goods the tendency was rather away from its increased use, for every man's goods found and held a market on their merits. Those who used shoddy did so at their own risk, and their goods passed for what they were. When the Wilson tariff removed the barrier against the importation of shoddy and shoddy goods the situation changed in the twinkling of an eye. More shoddy goods are made in England than in all the rest of the world put together. They have learned there, by long experience, the art of utilizing to the best advantage every kind of refuse that comes from rags and wastes. Let it have but two ends, they will find a way to spin it. These were the goods, among other varieties, which began to pour into the United States when the bars were let down. These were the goods with which American mills had at once to compete. In order to compete it was necessary to use the same kind of materials they use at Batley and Dewsbury. Cheap as wool was, it was not cheap enough to compete with English and continental rags. Deterioration in quality has been the distinguishing result, both as to imported and domestic woolens, of the tariff of 1894.

There was no material change under the law of 1894 in the quantity of carpets, ready-made clothing, or yarns imported. The sophistication and adulteration of our clothing supplies naturally came through cloths, and the abnormal increase was in this class and in women's dress goods. The following is a statement of the number of square yards and value of cloths imported in three-year periods under different tariffs:

Amount and value of woolen cloths imported, 1892–1900, showing effect of tariff laws.

Year ended June 30—	Law of 1890.		Law of 1894.		Law of 1897.	
	Amount.	Value.	Amount.	Value.	Amount.	Value.
	Yards.		*Yards.*		*Yards.*	
1892	13,813,276	$12,765,044				
1893	18,206,001	15,117,564				
1894	7,456,417	6,256,321				
1895			23,917,011	$16,298,169		
1896			36,781,572	21,886,528		
1897			27,859,311	17,007,273		
1898					5,062,261	$3,965,577
1899					4,092,898	3,909,466
1900					5,154,674	5,129,831
Average	13,158,564	11,546,309	29,519,298	18,397,323	4,769,944	4,334,958

This shows that the average annual importation of 13,158,564 pounds was increased to 29,519,298 pounds, an increase of about 123 per cent. This is not all, nor the worst. It shows the degradation of quality; that a large part of these goods were mixtures of the lowest order of waste, for notwithstanding the considerable requirement of fine cloths for the higher grades of fashionable tailoring, the mass of importation for the wants of plain people was of so low a character as to reduce the average price per pound for good and bad cloths from about 88 cents to 62 cents, a decrease of 30 per cent. These are the prices abroad, and they indicate the degeneration of

quality of the clothing supply. Added to this flood of foreign goods, the enormous quantities of "wastes" above mentioned kept the shoddy mills in activity day and night, swelling the stocks of worthless goods and forcing the manufacturers of honest cloths into retirement. In the last three fiscal years, not only have imports of woolen cloths fallen to one-third of the amounts imported under the act of 1890, but the increase in value per yard shows the improved quality of the goods imported.

The dress goods of women were greatly increased in quantity, but they were reported in pounds, while under the law of 1890 quantities were stated in square yards, so that comparison of quantities can not be made, but the annual average value of dress goods imports was increased from $13,846,250 to $17,039,070, a large increase, but not at all proportionate to that of cloths, the shoddy element not being so available for women's dress goods.

The total value of imported manufactures of wool was increased under the law of 1894, notwithstanding the lower value of inferior cloths, from an average of $31,017,922 per annum to $47,065,760.

These facts effectually refute the prophecy of a better clothing supply from free wool, and disclose a demoralization of manufactures and deterioration of goods such as never were known in the previous history of the country.

The prophecy that the law of 1894 would result in a full domestic supply of American manufacture, and an export trade in the surplus, was not only discredited but all our markets were glutted with foreign goods. The value of annual exports of all domestic manufactures of wool never rose to $1,000,000 until 1898, under the Dingley tariff. The predicted prosperity of the woolen manufacturing industry as the result of the tariff revision of 1894 failed to materialize, and instead an era of discouragement and disaster set in unparalleled in its history. Secretary North testified of it:

> During a great part of this period the bulk of the woolen and worsted machinery of the country has been wholly or partially idle; much of the remainder has made goods that have either been marketed at a loss or are still in stock. The domestic market for woolen goods has since been in a state of absolute demoralization.

He also declared that "we have in the United States enough woolen machinery, when in operation, to supply all the goods our people can consume."

He further stated:

> The removal of the weight duties of previous tariffs let down the bars to the importation of kinds and grades of cloth hitherto practically excluded from this country, an exclusion greatly to the advantage of our own people, as we now know. The ad valorem basis of the tariff has allowed the importation of the lowest and meanest descriptions of goods made in the world—the peculiar products of the Batley and Dewsbury districts in England, where they have reduced to an exact science the business of making woolens out of shoddy, mungo, wastes, cows' hair, and other

rubbish, in the spinning and weaving of which our American manufacturers have not yet learned the rudiments, although it is clear they will have to learn them if they have got to fight these goods in the home market. Immense quantities of these goods have been thrust upon this market under the present law. They are admirably manufactured, considering the material employed, and while worthless for wear are particularly attractive and deceptive in finish and appearance.

There never was a more total failure of fulfillment of prophecy, or a more complete refutation of an industrial fallacy, than that furnished by American experience with free wool.

As a result of the act of 1894, instead of 50,000 more operatives, half of all were out of employment in 1896, with a great and disastrous loss of wages. The demand for domestic wool was reduced as never before, and prices fell more than half, as stacks of foreign wool were piled up in importing warehouses. Wages, instead of increasing, were not merely reduced, but cut off totally for the multitudes unemployed, to whom employment at half pay was better than starvation.

The losses inflicted upon capital and labor during the industrial depression of these three years were enormous. Capital lost its profit first, and afterwards principal, with shrinkage of values, inability to sell products, and deterioration of idle machinery. Labor lost wages, means of living, comfort, and health. It is not easy to calculate the magnitude of these losses in an industry which by the census of 1890 had attained a production valued at over $300,000,000 per annum. It not only affected the factory population, but indirectly every industry of the country, and was the largest factor in intensifying the depression which reduced all values of real and personal estate, and, with few exceptions, all incomes and means of living. In the full measure of their extent these losses were incalculable and irreparable.

The total losses of this period of three years in the matter of wool and its manufacture alone were probably greater than those of the Spanish war and Philippine rebellion of the last two years; but its consequences were more far-reaching "in destroying confidence and markets," as stated in 1896, in the Bulletin of Wool Manufacturers, so that "other industries, at which the tariff of 1894 struck less vindictively, have suffered and are suffering."

THE PRESENT CONDITION OF SHEEP HUSBANDRY.

The flocks of the United States do not aggregate so large a number of sheep as in 1893, or in 1884, but they are increasing rapidly, and bid fair to exceed before many seasons the highest former figures. They include a greater variety than at any former period. If manufacturers desire a selection from all the wools in the world, they can get all varieties of much value without going out of the country. That this is no idle boast can readily be proved in our principal wool

markets. A glance at the registry and other breed associations shown in the appendix to the Yearbook of the Department of Agriculture for 1899, will go far to substantiate the same fact. There are the Standard Merino Registry Association, the Vermont Atwood Club Registry, the United States Merino Sheep Breeding Registry Association, the Dickinson Merino Sheep Record Company, the American Merino Sheep Registry, and the American Shropshire Registry Association. Then there are the Vermont Merino Sheep Breeding Association, the New York State American Merino Sheep Breeders' Association, the Ohio Spanish Merino Sheep Breeders' Association, the Michigan Merino Breeders' Association, the National Improved Saxony Merino Sheep Breeders' Association, the Black-Top Spanish Merino Sheep Breeders' Association, the Improved Black-Top Merino Sheep Breeders' Association, the Delaine Merino Sheep Breeding Association, the Improved Delaine Merino Sheep Breeders' Association, the Pennsylvania and Ohio Improved Delaine Sheep Breeders' Association, and the American Rambouillet Sheep Breeders' Association; of the long wools, the American Cotswold Association, the American Leicester Breeders' Association, the American Lincoln Breeders' Association, the National Lincoln Sheep Breeders' Association, and the National Cheviot Sheep Association; of the middle and short wools the various Downs, the Southdown Association, the Oxford Down Association, the Suffolk Association, the Dorset Horn Sheep Breeders' Association of America, and the Continental Dorset Club. And there are others, including an association of breeders of the fat-tailed Tunis sheep.

In collecting the wool exhibit for the Paris Exposition of 1900, the writer was impressed with the wonderful progress that has been made in diversification of breeds and qualities of wool. The same skillful and patient work that resulted in the differentiation of the old Spanish Merino, giving the world the French, Saxon, Silesian, and American Merinoes, has been continued with the latter in the Delaine and Black-Top families (or breeds), with heavier bodies, longer fiber, and more valuable fleece for the finer combing fabrics so much in demand for the fashionable tissues for ladies' and children's wear. The Lincolns, that have played so important a part in the recent breeding of Australia and South America, are here in force and can be produced in any quantity desired, answering the demand for lustrous combing wools.

The wool exhibits now on exhibition at Paris include samples of nearly all breeds and grades of our domestic wool. They fill twenty-one sections, each covered with a plate glass 5 feet in height by 3 in width. Thirteen of these show whole fleeces, twelve in each, from the wool dealers in the two great markets, Boston and Philadelphia, illustrating the various qualities and commercial classifications of

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American wools. Seven section cases are filled with samples from breeders of nearly all the breeds, samples of eighty-four fleeces from the farming States, the mountain ranges, and the Pacific coast. More than half are Merino, but the several Delaine breeds outnumber the original American Merinos, illustrating the present popularity and general distribution of the long-fiber combing-wool types, of which the Standard Delaines are the most numerous, representing breeding flocks in Ohio and Texas, one of the latter a fleece from a 2-year-old, weighing 24½ pounds, from W. S. Beck, of Coleman, Tex. The National Delaine exhibits are from Pennsylvania and Ohio, the fleeces being quite uniform in weight—from 15 to 17 pounds—one fleece, from Mr. James S. McNary, of Canonsburg, Pa., weighing 17 pounds. The National Dickinson Delaines are from Ohio breeders, the extreme weight of fleece being 16 pounds. Pennsylvania and Ohio also furnish the Black-Top Delaines, of which one fleece weighs 18 pounds, from Mr. M. M. Keener, of Plaingrove, Pa. There are also Delaines from Missouri, Iowa, and California. The American Rambouillets, with fleeces up to 16 pounds, are from New York, Ohio, and Michigan. The fine Saxony fleeces are from the veteran breeder, Mr. John G. Clarke, of Washington, Pa., one fleece from a yearling weighing 5½ pounds. Another Saxon exhibit is from Virginia. The larger proportion of Merino fleeces come from California, others from Texas, Indiana, Michigan, Ohio, and New York.

Among the Downs the Shropshires are the most numerous, coming from breeders in Missouri, Iowa, South Dakota, and Oregon, with fleeces up to 12 pounds. Southdowns are from Vermont, Ohio, and Illinois, the heaviest fleece 10 pounds. Oxfords represent Ohio and Illinois, one fleece weighing 14 pounds. Dorset Horn fleeces come from New York, New Jersey, Pennsylvania, and Ohio, and weigh from 7 to 14 pounds. Lincolns, very popular in range districts, are unrepresented. Other exhibits are Cotswold from Oregon, one from the Agricultural College weighing 19 pounds, Leicester and Cheviot from Indiana. There are four samples of the North Star breed from Minnesota, evidently from crossing of fine and long wools, weighing 16 pounds per fleece. As a curiosity a sample of very long fiber from Alaska is included. There is also a case of twenty-four samples of Angora goat fleece, mostly selected by William R. Payne & Co., wool dealers of New York, and coming from W. G. Hughes of Hastings, Tex., John S. Harris of Oakley, Idaho, and George S. Houk of Oregon.

These exhibits will give the people of other countries an idea of the great variety and high character of American wools, and illustrate attainments in breeding that leave little necessity for importing either sheep or wool. There are very few of the breeds of the world worth importing that are not already here, and being improved rather than

deteriorating. Our climates and grasses furnish sufficient diversity and variety to meet all requirements.

From Maine to Texas, from Alaska to Arizona, are found conditions of temperature, humidity, and pasturage, comparatively free from extremes of drought such as have destroyed sheep by thousands in Australia and Argentina, and favorable to great variety and high quality of American wools.

The general feeling at the present time as to the condition and prospects of sheep husbandry is one of relative content and satisfaction, and of confidence and hopefulness for the future. If all growers are not equally suited and satisfied, they are at least measurably content with the situation. The one thing that they dread is a violent change of conditions. In a country that is continental in extent, conditions can not be equally favorable in all sections. There are differences in climate, some districts requiring feed and shelter all winter; others needing neither at any time, except in severe storms that may or may not occur during an entire winter. Some sections have limited pasturage, required imperatively for other kinds of stock; others have broad prairies, or wide stretches of free range.

Western competition has borne heavily on the seaboard States in this as in other branches of animal industry. The effect has been the movement of live-stock industries westward for the past fifty years. As the farm dairy of the Alleghanian slope has existed for the supply of fresh milk to dense neighboring populations, so have sheep been maintained to a limited extent for the production of early lambs, though this industry has suffered from competition since the advent of refrigerator cars.

The decline of flocks has been steady in New England for fifty years. Not only has every decade witnessed a diminution in numbers, as a whole, but in every State the progressive decline has been without a break, with a single exception, Maine having shown an increase in 1880, and a very slight gain in 1860, although there were nearly four times as many sheep in 1850 as in 1900. Vermont in 1850 had nearly half of all the sheep enumerated in the New England States, and while her American Merinos have taken European medals, and have gone to Australia and South America in exchange for generous sums in gold, her flocks declined from 1,014,122 in 1850 to 752,201 in 1860, and 580,347 in 1870, in an era of popularity in which $5,000 was offered and refused for a single sire. This means simply that while there was profit in breeding flocks of high repute, the larger numbers suffered from the general tendency to decline of common flocks. There is a feeling now, among those having former experience, that there may be profit in sheep again for the production of fat lambs, but whether it will lead to increase of flocks is uncertain. With skill and enterprise it might prove so. Few farmers there will be likely to give the requisite attention, and few have pasturage sufficient to support a paying business. If a few get Shrop-

shire or Dorset sires, raise a few crossbred lambs, and sell them for the prices local butchers pay for the common stock, the profit will not prove alluring. There are some, however, who find a profit in such lambs, and more can do the same with the enterprise and energy put into other business in this region.

The conditions in the Middle States are essentially the same as those of the Eastern. The decline in numbers of sheep has been progressive, decade by decade, without a break, except in Pennsylvania, where in 1870 and 1880 increase was shown, owing to prominence of the Panhandle counties in woolgrowing in that period of general prosperity. The decline from 1850 to 1890 was small in Pennsylvania; it was continuous in New Jersey, though there were only 160,488 in 1850; but in New York the falling off was from 3,453,241 in 1850 to 1,528,979 in 1890, and in the last ten years the reduction has been almost half the figures for 1890. Now there are only about a third as many in the Middle States as in 1850—a few breeding flocks, some held for raising spring lambs, and scattered farm flocks. A few can now find a profit under present conditions in pure-bred flocks for fortifying the blood of the mountain-range flocks. The history of the past is no guaranty of future increase, though it may be possible, dependent upon the comparative profit of dairying and other lines of eastern rural industries. The only item of advantage enjoyed by this Atlantic seaboard region in woolgrowing over the far West is in lower transportation charges, and this by no means offsets the advantages of that region.

A letter from the secretary of the New York State American Merino Sheep Breeders' Association, Mr. J. H. Earll, states that flock owners are generally well satisfied with present conditions, as wool at 20 cents and lambs at $4 in July "pay very well." Most of the sheep are of the mutton breeds, the tendency having been in that direction for ten years past. He states that the Shropshire leads all other breeds. In 1888 there were 150 registered fine-wool flocks in the State; now there are about 50. But owners have taken courage from increase of price—from 7 and 8 cents in 1895 to 20 cents in December last, though now temporarily a little lower. They are confident of good prices later.

The Southern States, exclusive of Texas, had between 5,000,000 and 6,000,000 sheep in 1850, and there have been only slight fluctuations since, the census of 1890 showing over 5,000,000. The South has never been a woolgrowing region. Its present opportunity is in feeding lambs and muttons, for which great natural resources are enjoyed—a mild climate that requires little if any shelter and permits the growth of forage all winter, while its cotton seed is a valuable and abundant element of feeding rations. Its population furnishes an extensive market for meats, in which a high quality of mutton, as well as beef, is now scarce. Eastern and foreign markets would furnish a profitable outlet for any surplus that might be produced. In the meat-making branch of sheep husbandry there should be a large increase, climatic

and feeding resources being unexcelled by those of any other States, the most serious obstacles being dogs and an indisposition to undertake new rural enterprises.

Throughout the West a buoyant feeling exists among sheep raisers, and numbers are increasing with considerable rapidity, especially in the valleys of the Mississippi and Missouri. The impulse of growth is felt in all the States of the Ohio Valley.

In Indiana, which has never been a distinctly woolgrowing State, according to Prof. C. S. Plumb the "sheep and wool interests are destined to a very considerable increase." He says it is many years since Indiana has had as many sheep as to-day. In breeding, the value of a good mutton carcass is not lost sight of, while wool is an important consideration. The Rambouillet Merino is now very popular there, and the Delaine Merinos are held in high esteem. The sheep of Indiana are mainly of the mutton breeds, though there is now a tendency to cross with Merinos of large size that approach the mutton conformation. Shropshire grades are now predominant, and many growers incline toward the Rambouillet as an improving cross.

The Secretary of the Indiana Dickinson Delaine Association, Mr. U. C. Brouse, says this breed has been very popular because of a strong constitution, good feeding quality, mutton forms, and heavy fleeces of valuable wool. He says there are about 8,000 registered, mostly in Pennsylvania, Ohio, Indiana, and Michigan.

There is rapid increase of flocks in the prairie States west of the Mississippi. Iowa is perhaps more interested in sheep husbandry than ever before. Sheep are increasing quite rapidly in Minnesota and the Dakotas, and numbers are now greater than at any former period. The feeling is general that under present conditions sheep should prove fully as profitable as any other branch of stock raising.

The region west of the prairies, the range country, including Texas and the Pacific Coast, is the principal area of American woolgrowing. In all this region the industry is now flourishing. Sheep are increasing, the flock masters have the confidence and courage to extend operations, use their time and money in efforts for breed improvement, and give the care and attention to details necessary for the permanent welfare of flocks. Everywhere they appear to be content with the situation.

Advices from Montana and Wyoming, where sheep are counted by millions, and valued as never before, the total value of the flocks of the former being greater than that of any other State, and of the latter only exceeded by that of Ohio, declare a condition of prosperity and contentment. Similar conditions are reported in Utah and Idaho.

New Mexico is credited with the largest number of any State or Territory. The Department of Agriculture estimates 3,397,439; and Governor Otero estimates last year's product of wool at over 18,000,000 pounds and declares that sheep husbandry is now the most prosperous

industry in the Territory and flock masters are in better spirits than for many years. Many years have been occupied in breeding up the coarse-wooled Mexican stock to the Merino plane, yet the wool is still uneven, some fleeces comparing favorably with any in the United States, while the majority are not uniform in grade, running from fine to blanket wool; but each succeeding year the lambs produce a finer grade of wool. A scouring mill in Las Vegas, in its records, indicates this diversity. One clip of 90,000 pounds of grease wool scoured 97 per cent of fine and fine medium, 2 per cent of quarter blood, and 1 per cent of blanket. One of 77,000 pounds of grease wool yielded 90 per cent of fine and medium, 9 of medium, and 1 of blanket. Another of 40,000 pounds scoured 65 per cent of fine and 35 per cent of medium. These indicate a high grade of improvement. Others were not so good. One clip of 31,000 pounds gave only 2 per cent of scoured fine medium, 59 of three-eighths, 17 of quarter blood, 18 of blanket, and 4 of carpet wool. This is coarse but serviceable wool, with little of its original carpet quality.

The industry is also quite prosperous in Arizona, and sheep are increasing rapidly.

The secretary of the National Merino Sheep Register Association, of California, Mr. R. O. Logan, says that woolgrowers are generally jubilant over present prospects, over the return of a fine-wool period, feeling that the tendency of the next decade will be toward the growing of merino wool of long staple. The only serious drawback indicated is the introduction of skirted wools at the rate of unwashed, which reduces materially the protective benefit of the duty.

Oregon and Washington flocks are increasing in numbers, giving a reasonable profit to flock owners and a measure of satisfaction and contentment.

The present condition of woolgrowing has no more suggestive index than the average prices of January last. In the twelve States and Territories which now produce nearly two-thirds of all our wool, the prices of sheep are higher in every one than in January, 1893. In Oregon, Wyoming, and New Mexico the average price was more than double that of 1895, and for all of them together the average was little short of double, and the home price of wool has increased more than 100 per cent. A comparison of January prices in 1893, 1895, and 1900 is as follows:

Prices of sheep in Far West in 1893, 1895, and 1900, compared.

States and Territories.	1893.	1895.	1900.	States and Territories.	1893.	1895.	1900.
Texas	$1.60	$1.21	$1.92	Utah	$2.38	$1.47	$2.59
Montana	2.58	1.51	2.84	Nevada	2.43	2.42	2.91
Wyoming	2.75	1.64	3.51	Idaho	2.50	1.41	2.80
Colorado	2.52	1.52	2.86	Washington	2.83	1.74	3.13
New Mexico	1.50	.90	2.17	Oregon	2.40	1.16	2.67
Arizona	2.25	1.21	2.31	California	2.32	1.65	2.85

Woolgrowers regard with interest the effect of the present tariff on the price of their wools. When the enactment of 1897 went into operation as to wool August 28, 1897, and as to shoddy and other manufactures January 1, 1898, some may have expected an advance equal to the rate of duty. But this by no means occurred. The markets were then full of fine foreign wool, and two or three years of mill consumption were necessary to clear away these stocks. The diagrams (figs. 2 and 3), prepared by Justice, Bateman & Co., wool

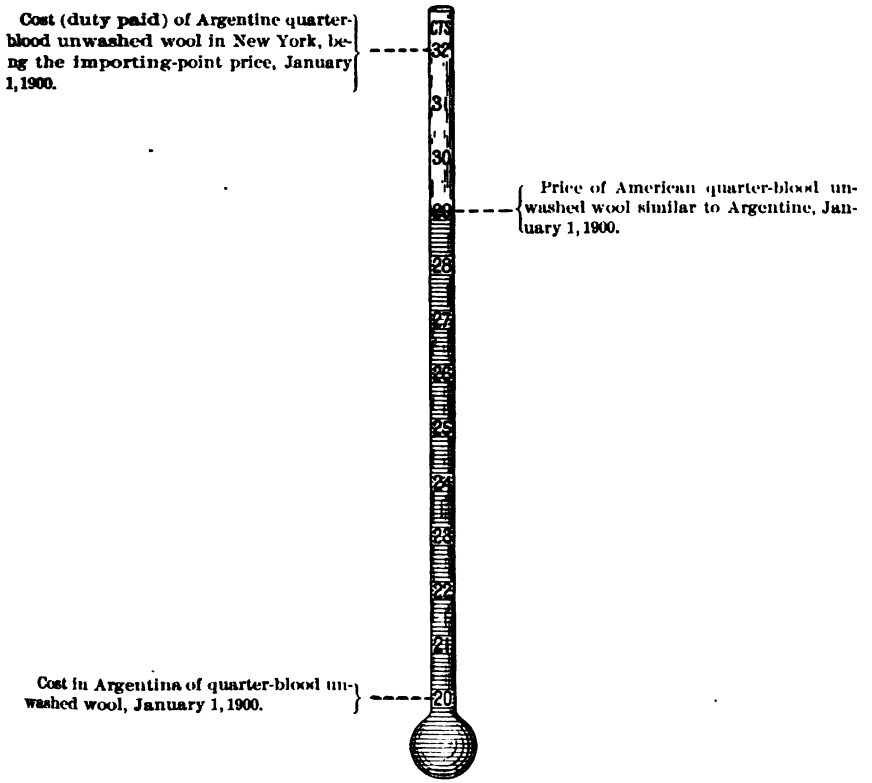
Cost (duty paid) of Argentine quarter-blood unwashed wool in New York, being the importing-point price, January 1, 1900.
Price of American quarter-blood unwashed wool similar to Argentine, January 1, 1900.
Cost in Argentina of quarter-blood unwashed wool, January 1, 1900.
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FIG. 2.—Diagram showing effect of Dingley tariff act in raising the price of American wool, January 1, 1900—only three-fourths of its lifting power realized.

dealers, of Philadelphia, illustrate clearly and accurately the price-lifting force of the Dingley tariff. The representative grade of American wool in the diagram is quarter-blood unwashed, which represents wool from mutton sheep of the Shropshire or similar flocks. Fig. 2 shows that only 75 per cent of the price-lifting effect of the tariff was attained by January 1, 1900. Justice, Bateman & Co. say in explanation:

Argentine crossbred wools, spinning to what are known here as 46s to 50s qualities, corresponding to an American medium in the unwashed condition, but skirted, now

cost in the Argentine Republic 20 cents. With 1 cent added for freight the cost afloat in New York would not be under 21 cents, but with the Dingley tariff duty of 11 cents added the cost to the American consumer would be 32 cents for wool of the same class and quality as domestic unwashed medium combing, the outside price for which on January 1 was 29 cents. Thus it would appear that an effort is being made to reduce the duties of the Dingley act before it has had a trial.

This reference to reduction of duties relates to the proposed Argentine reciprocity treaty, which makes a reduction of 20 per cent.

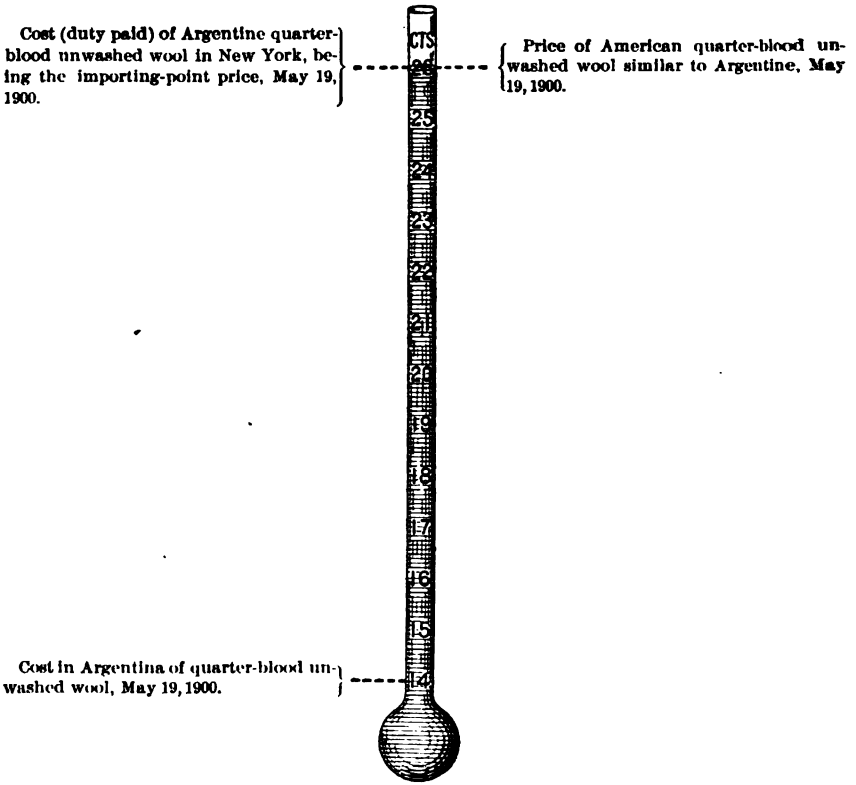

FIG. 3.—Diagram showing effect of Dingley tariff act in raising the price of American wool, May 19, 1900—its full lifting power realized.

Since January 1 there has been a 30 per cent decline in the markets of the world on Argentine quarter-blood unwashed, which realized the full price-lifting effect of the tariff, i. e., the American price is as much above the foreign price as the Argentine price, plus 11 cents duty and 1 cent freight; in other words, it is 12 cents below the American price, which is 26 cents, as shown in figure 3.

Thus it has been between two and three years since the tariff went into force before its full effect could be realized on quarter-blood unwashed wool in comparison with Shropshire or similar American wool.

The data presented in this report show that this country produces wool suited to almost every variety of honest fabric that is made; that, excepting the lower grade of wools, domestic manufacture has at some dates had a nearly full supply; that in a very brief period a full supply of clothing and worsted wools can be reasonably expected. It has also been shown that our manufacturers can not be successful without a comparatively full supply of home-grown wools.

In conclusion, it has been fully demonstrated, and needed not the bitter experience of 1894–1897 for emphasis, that the prosperity of manufacturers is inseparably bound up with that of the woolgrowers. A full supply of wool products for domestic consumption can easily be produced for a constantly increasing population, and ultimately some for exportation is possible, but never with foreign wool. In some lines even now foreign shipments of manufactures of wool are made and they are increasing. During the fiscal year ended June 30, 1900, the value of exports of wool manufactures was $1,253,602 against $1,047,407 in the preceding fiscal year, largely in wearing apparel. This will increase if the prosperity of both industries is maintained.

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U. S. DEPARTMENT OF AGRICULTURE.

Report No. 67.

LIBRARY OF THE UNIVERSITY OF ILLINOIS

FOREIGN MARKETS

FOR

AMERICAN AGRICULTURAL PRODUCTS.

TESTIMONY

OF

FRANK H. HITCHCOCK,

Chief of the Section of Foreign Markets,

BEFORE

THE INDUSTRIAL COMMISSION.

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FOREIGN MARKETS

FOR

AMERICAN AGRICULTURAL PRODUCTS.

TESTIMONY

OF

FRANK H. HITCHCOCK,

Chief of the Section of Foreign Markets,

BEFORE

THE INDUSTRIAL COMMISSION.

WASHINGTON:

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
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SIR: On June 13 and 15, 1900, Mr. Frank H. Hitchcock, Chief of the Section of Foreign Markets, appeared as a witness before the United States Industrial Commission by the invitation of that body. His testimony covered especially the relations to and dependence upon agriculture of our foreign trade, and served to bring together in convenient form a large amount of information not hitherto published by the Department. The demand for this information is frequent and widespread, and as the suggestions offered by Mr. Hitchcock in response to the inquiries propounded to him by the Commission are such as have frequently met with your expressed approval, I earnestly recommend the republication of this testimony as a departmental report.

Very respectfully,

GEO. WM. HILL,
Editor.

Hon. JAMES WILSON,
Secretary of Agriculture.

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FOREIGN MARKETS FOR AMERICAN AGRICULTURAL PRODUCTS.

INTRODUCTORY.

At the meeting of the United States Industrial Commission on June 13, 1900, at Washington, D. C., Mr. Farquhar presiding, Mr. Frank H. Hitchcock, chief of the Section of Foreign Markets, United States Department of Agriculture, was introduced as a witness, and, being duly sworn, testified as follows:

Q. (By Mr. A. L. HARRIS.) You may state your name, your address, and your occupation.—A. My name is Frank H. Hitchcock; my occupation is that of chief of the Section of Foreign Markets, United States Department of Agriculture; that is also my address.

Q. How long have you been connected with the Department of Agriculture?—A. Since the autumn of 1891.

Q. And all that time in this bureau?—A. No. I went into the Department as a biologist, passing the civil-service examination. I served in the biological work for one year and then took up the statistical work. I worked in the statistical bureau until about five years ago, when I was transferred to the Section of Foreign Markets soon after its inception. My work has therefore been statistical for about eight years.

Q. Your examination has been exclusively in the line of the extension of foreign markets for agricultural products?—A. Yes; since I have been connected with my present office.

Q. What means have you had for procuring your information in regard to the expansion of foreign markets for agricultural products?—A. We have had, first of all, the published information that is issued by the various foreign governments. We depend upon the official reports, as far as possible, for our information, especially for our statistical information. We have also had the cooperation of the United States consular service through the courtesy of the State Department. The consuls have furnished us with reports on stated topics, the inquiries being transmitted to them through the Department of State. In addition to that we have had some assistance from employees of our own Department abroad. There have been several special agents (so called) employed to study agricultural conditions in foreign countries, and they have reported to the Department. For

information on the subject of our own export trade we are of course dependent very largely upon the reports of our customs officials as published by the Treasury Department.

EXTENT AND INCREASE OF AGRICULTURAL EXPORTS.

Q. You may state, if you will, in your own way, the past conditions of the foreign markets for agricultural products, the present conditions, and the hopes for the future.—A. The extent to which American farmers depend upon foreign markets for the disposal of their surplus products may be gathered from the fact that during the past fiscal year, 1899, our agricultural exports reached in value close to the enormous sum of $800,000,000. The agricultural exports probably comprise about 25 per cent of the total production of American agriculture. With this enormous surplus the acquirement and maintenance of a ready foreign market is of the greatest importance to our agricultural interests. In order to prevent the glutting of the home market we must ship our surplus produce to foreign countries.

During the last forty or fifty years our agricultural exports have increased with great rapidity. In 1860 their value was about $258,000,000; in 1870 it amounted to $363,000,000;[1] in 1880 to $693,000,000; in 1890 to $635,000,000; and in 1899 to $793,000,000. Comparing 1860 with 1899, the last year for which we have figures, a period of about forty years, we find an increase of over 200 per cent.

Every indication points to the probability of a still further increase in our agricultural export trade, providing proper measures are taken to foster it. Modern transportation facilities are revolutionizing the character of the trade. The introduction of cold storage and of refrigeration service on railway cars and steamships is making it possible to market in foreign countries across the sea products that we were formerly unable to export; and it is along this line of development that the increase of our export trade in agricultural products in the future may be chiefly expected—in the exportation of perishable products, such as meats, butter and cheese, perishable vegetables, and fruits.

FRESH BEEF.

Thus far the chief example of trade development along this line is found in the case of fresh beef. In 1880 our exports of fresh beef were valued at about $7,000,000. Last year, 1899, they were valued at $24,000,000.

INDIAN CORN.

Some of the other products that show an increased exportation, but mainly for other reasons, I will now mention. Corn is a notable

[1 The figures for 1870, quoted in this testimony, represent the currency export values, as originally published in the official customs returns.]

example. In 1870 we exported a little over $1,000,000 worth of indian corn. Last year we exported nearly $70,000,000 worth. The development of the dairy industry all over the world and the discovery in foreign countries that American corn forms a cheap and desirable feed stuff for live stock have led to an enormous increase in our exportation of that grain.

WHEAT FLOUR.

Another conspicuous example of increase is wheat flour. Going back to 1870 we find that the exports of wheat flour were valued at about $20,000,000. Last year, 1899, they were valued at $73,000,000. The remarkable development of the milling industries in this country, resulting in a very large production of high-grade flour at a low cost, has made it possible for us to export flour in competition with other producing countries and gradually to get the trade. Flour affords one of the most notable instances of increase among our agricultural exports.

CATTLE.

Another case of development in the agricultural export trade is that of the shipment of cattle. In 1870 our cattle exports amounted in value to less than $500,000. In 1899 they amounted to over $30,000,000. This trade has been greatly aided, of course, by the changes in the methods of transportation, the improvement of transportation facilities, the shortening of the time in which live cattle can be transported, not only across the continent but across the sea, and by the measures that have been taken by the Government to protect and foster the trade. The official inspection of export cattle, guaranteeing a standard in condition and quality, has greatly benefited the export trade.

CURED MEATS.

Our exports of cured meats have also increased to a noticeable extent. The various pork products, in particular, have presented a very marked example of increase. In 1870 we exported only about $6,000,000 worth of bacon and hams, while in 1899 we sent abroad over $60,000,000 worth. Our bacon exports for 1899 were valued at $42,000,000, and our ham exports at $21,000,000.

LARD.

Similarly the exports of lard have grown enormously in the period under consideration. In 1870 we exported about $6,000,000 worth of lard. In 1899 we exported $42,000,000 worth. The growth of the packing industry in the United States and the improved methods of packing that have been adopted here have resulted in a great development of this export trade.

OIL CAKE.

Another agricultural export that shows a very large growth and a very rapid one is oil cake and oil-cake meal. In 1870 we exported about $3,500,000 worth of oil cake and oil-cake meal. Last year we exported $14,500,000 worth. This product presents a case somewhat similar to that of the exports of corn. It is beginning to be fed very largely to live stock abroad, especially in dairying countries. Foreign dairying interests are beginning to discover its utility as a feed and are importing it in rapidly increasing quantities.

COTTON-SEED OIL.

Another article that shows a rapid increase is cotton-seed oil. In 1870 we exported only about $15,000 worth of this product. In 1899 we sent abroad about $12,000,000 worth.

OLEO OIL.

Oleo oil, a product that has come to the front somewhat recently, affords another instance of growing export trade. In 1870 no exports were recorded. In 1880 about $2,000,000 worth went to foreign markets, and in 1899 over $9,000,000 worth. Oleo oil is sent abroad to countries that manufacture oleomargarine; it is sent abroad in the crude form and is used in the manufacture of imitation butter.

FRUITS.

Still another item is fruits. Our export trade in fruits has increased with considerable rapidity during these years. In 1870 we shipped to foreign countries about $500,000 worth, whereas in 1899 we exported nearly $8,000,000 worth.

The leading articles just enumerated are the ones that have contributed most to the general increase I spoke of as having occurred in our agricultural export trade.

REASON FOR SELECTING STATISTICS QUOTED.

Q. (By Senator KYLE.) Why is it you take a period of thirty years—1870 to 1900?—A. One reason is that the statistics prior to 1870 are not in such satisfactory shape. I have here the figures for each decennial period from 1870 down to 1899.

Q. Is there a falling off in the different periods between 1870 and 1900?—A. There is a fluctuation in some cases—a falling off followed by a recovery.

Q. And then a rise again in the last two or three years?—A. A rise occurred in many cases during the last two or three years.

DISTRIBUTION OF EXPORT TRADE.

Q. I would rather like to hear the destinations of these agricultural products, if you can give them just as well as not.—A. As regards the

distribution of our agricultural exports in general, I will say that the United Kingdom is, of course, our most important market. We send over one-half of all our agricultural exports to the United Kingdom of Great Britain and Ireland. Of the products exported during the five years 1894–1898, measured in value, about 55 per cent went to the United Kingdom. Thirteen per cent of the exports for the same period went to Germany; to France, 6.6 per cent; to the Netherlands, 4.3 per cent; to Belgium, 3.6 per cent. These five countries are the destinations of a very large proportion of our European trade, and, in fact, of our total export trade in agricultural products.

Q. Why do you select the period of 1894 to 1898?—A. The reason I have selected that period in this testimony is because I have published a report upon our agricultural export trade for those years, from which I am able to quote. The report was issued some little time ago, and so it does not include 1899. Similar statistics covering 1899 have not yet been published.

Q. Do these percentages materially differ as regards other periods?—A. Not materially. I am speaking now in reference to the present status of the export trade, and it is fairer to take a period of several years and give the average than to quote any single year. The average for the five years 1894–1898 gives a fairly accurate idea of the present distribution of the export trade. Of our agricultural exports for that period about 88 per cent went to European countries. That shows how important Europe is to us as a market.

Q. You figure with that, of course, the export trade from the Pacific coast?—A. The entire agricultural export trade of the United States.

INCREASE OF TRADE TO ASIATIC COUNTRIES.

Q. Do you think in the period from 1894 to 1898 there has been an increased trade from the Pacific coast to the Asiatic countries?—A. There has been a marked increase during that period. The total value of our agricultural exports to Asia increased from less than $4,000,000 in 1894 to nearly $15,000,000 in 1898. The agricultural exports to Oceania, which are stated separately, increased in the same period from less than $2,000,000 to $3,500,000—quite a material increase. The increase shown by the Asiatic and Oceanian trade is proportionately very much greater than the increase shown in any other direction. It is about the most interesting feature of our recent foreign-trade development.

COTTON.

Q. What are the branches of our trade that are increasing in the last three or four years from the Pacific coast?—A. As regards the agricultural exports, the chief articles are cotton and wheat flour. I will quote from one of my reports statistics to show how the export trade in cotton has developed. Our total exports of raw cotton to

Japan, China, and Hongkong increased from 23,500 pounds in 1889, ten years ago, to nearly 119,000,000 pounds in 1898. The present trade represents the growth of little more than a decade. To show how rapidly it has developed in the last year or two, I will say that in 1897 the exports amounted to only 32,000,000 pounds, as compared with nearly 119,000,000 pounds in 1898.

Q. Have you any figures to show the increase of the production of China during this same period? Were they increasing materially in the production of cotton?—A. Not materially. Very little increase is shown by the statistics of cotton production in China.

Q. So that the inference, then, is that they are wearing more cotton, they are consuming more cotton goods?—A. The raw cotton, I will say, goes chiefly to Japan, where the manufacturing of cotton is rapidly coming into great prominence. The Japanese are now manufacturing enormous quantities of cotton goods. Their manufacturing has increased very rapidly in the last few years, and they are now drawing upon us quite extensively for their raw cotton. The natural inference would be that the use of cotton cloths is increasing in that portion of the world.

Our gains in exportation, however, are not confined entirely to the exports of the raw product. Our exports of cotton manufactures to the Orient also show a considerable increase. They have fluctuated considerably from year to year, but taking 1889 to 1898, a period of ten years, we find an increase from $1,600,000 worth in the former year to $5,300,000 worth in the latter year.

Q. Just in one year?—A. No; in ten years.

Q. In ten years an increase of $4,000,000. Well, is this a peculiar kind of cotton goods?—A. It is the style of cotton goods, of course, that is generally sent to tropical countries, largely cheap cottons of the coarser grades.

Q. From what section of the United States are these goods exported?—A. They come from the cotton manufacturing sections in New England and also from the South. I do not know as to the exact distribution, but I understand that the South is now beginning to export quite largely to the Orient.

Q. The South is manufacturing an article that is very largely consumed in the Orient, is it not?—A. I understand it is beginning to.

WHEAT FLOUR.

I spoke also of the exportation of wheat flour to the oriental countries; I will quote statistics to show the gain in the shipment of that product. In 1889 our exports of wheat flour to Japan, China, and Hongkong amounted to 408,000 barrels. In 1898 they amounted to 1,120,000 barrels. The increase was particularly marked in the last

few years of the decade. In 1894 they had increased to only 676,000 barrels; the advance to over a million occurred in the years following that.

DESTINATIONS OF LEADING EXPORTS.

At Senator Kyle's request I will now take up the leading products I have mentioned as showing gains in exportation and state briefly the principal destinations to which we are now sending them. Indian corn is the first item on my list. I will ask Senator Kyle whether he would prefer to have me state the distribution by quantities or by values?

Senator KYLE. I think value probably would be a sufficient indication.

Q. (By Mr. A. L. HARRIS.) Have you the bushels or weights in your statement?—A. I have both quantity and value wherever they can be stated. In the case of some items—for instance, fruits—only the value is recorded.

Q. (By Mr. FARQUHAR.) In the case of cereals, however?—A. The separate cereals are all stated by both quantity and value. To get at the volume of the exports it would be important, of course, to have the quantity as well as the value; but where you are simply showing the proportion of export trade that goes to the different countries the value forms a satisfactory basis as regards the distribution. In fact it makes very little difference in a given year whether we take the quantity or the value for that purpose. Such statements, whether stated in quantity or in value, are merely comparative. However, I can quote, if you wish, both quantities and values.

Mr. FARQUHAR. I think the commission would like to have both the quantity and the value.

WITNESS. To give a fair idea of the distribution I will take the average for the five-year period 1894–1898, stating the quantity and value for that period.

INDIAN CORN.

Speaking now of indian corn, our shipments of this grain to the United Kingdom averaged 50,000,000 bushels a year, the value being about $18,000,000. That gave the United Kingdom, taking the percentage of quantity, about 43 per cent of the total exports. Germany ranked next to the United Kingdom as a market for our corn, taking about 20,000,000 bushels a year, or about 17 per cent, the value being slightly more than $7,000,000. Canada was a market for about 10,500,000 bushels, the value being about $3,700,000. Canada took about 9 per cent of the total. The Netherlands, with 10,400,000 bushels, valued at $3,800,000, received nearly 9 per cent. Denmark took nearly 8 per cent, receiving about 9,000,000 bushels, with a value of about $3,000,000. These five countries—the United Kingdom, Ger-

many, Canada, the Netherlands, and Denmark—were the chief markets for our indian corn during the period under consideration. After these countries France and Belgium may be cited as the most important markets.

WHEAT FLOUR.

Wheat flour is the next item that I will mention. Of the wheat flour exported in the five-year period 1894–1898, the United Kingdom took about 58 per cent. The quantity sent to that country was, taking the annual average, about 9,000,000 barrels and the value about $35,000,000. Other destinations, the chief of which, however, the Netherlands, took only about 6 per cent, were, in the order of their importance, the Netherlands, Hongkong, Brazil, Canada, the British West Indies, Cuba, and Germany. I have mentioned all the destinations to which an average annual export of more than 200,000 barrels was sent.

Q. (By Senator KYLE.) Did you mention the Asiatic countries there in that list?—A. I mentioned the chief one—Hongkong. Hongkong ranks third.

Q. About what per cent?—A. It takes about 5 per cent of the flour.

Q. I would like to ask you whether the East Indies are finding a market for wheat and wheat flour in the Orient?—A. My impression is that they are not to any considerable extent. You refer to India?

Q. India; yes.—A. Not to any large extent. India is not developing as a wheat-exporting country. That country has not the importance that it formerly had as a source of supply. I have here the wheat production of British India. It fluctuates, of course, from year to year, but the general tendency has been downward.

Q. You may state for the information of the commission something about the production of British India.—A. There have been indications that the wheat production of India was declining, if anything, in recent years. For instance, the average annual production for the past five years, 1895–1899, amounted to something less than 230,000,000 bushels, whereas the average for the preceding five years, 1890–1894, was about 240,000,000 bushels. The average for the five years 1885–1889 was still larger, amounting to about 260,000,000 bushels.

CATTLE.

I was about to speak of the distribution of our export trade in cattle. The United Kingdom takes nearly 95 per cent of the live cattle shipped from the United States. The average number of head exported to the British market during the five years 1894–1898 was about 350,000 and the value about $33,000,000. It is the only market of importance we have for export cattle. The remainder of the trade is widely distributed among other countries.

I will mention as an interesting fact that we have recently been shipping quite a number of cattle to Cuba. In 1898 we shipped about 40,000 head. The importation of American live cattle into Germany, France, Belgium, and the Netherlands was prohibited some years ago, although I should say that Belgium has since removed the prohibition.

Q. (By Mr. A. L. HARRIS.) What was the reason of the prohibition?—A. The prohibition was enacted on the supposition that there was danger of introducing infectious diseases. Several years ago—I believe it was in 1894—there were some alleged cases of Texas fever in American cattle shipped to Hamburg. On the strength of that Germany prohibited the importation of live cattle from the United States, and these other countries afterwards took similar action.

Q. What action has been taken, if any, on the part of our Government to insure against the disease of Texas fever in the shipments from this country?—A. The inspection system of the Department of Agriculture is believed to be a very sure preventive of the exportation of diseased cattle. I think there is little danger of sending diseased cattle cut of this country under that system.

Q. But so far you have not been able to convince those countries that there is no danger?—A. There has been a great deal of correspondence between our Government, through the State Department, and foreign governments on that subject, but it has been very difficult to convince them. I do not know whether I should say this formally or not. I should like to say to the committee, informally, that it is believed to some extent that the restrictions put upon our exports are simply a pretext to keep them out in order to prevent competition. That is one reason why it has been so difficult to get some of these restrictions removed.

Q. (By Mr. FARQUHAR.) Is the action of Germany traceable to the so-called Agrarian party, or the Farmers' party, in the exclusion of the American product?—A. It is generally believed that the Agrarians are back of all these movements against our products, and that the real object is not so much to protect the German people from injury through disease as it is to protect their products against competition.

Q. (By Mr. A. L. HARRIS.) Where is the estimate of value placed, here in this country or where the cattle are delivered?—A. In the statistics I am quoting the value is the declared value here.

Q. (By Mr. FARQUHAR.) In the American custom-houses?—A. In the American custom-houses. I am now using United States statistics. The Germans, in preparing their statistics of importation, take the value in their own ports, based on the market price.

LARD.

The next product I have on the list is lard. The United Kingdom is also the chief market for our lard, Germany ranking second. A

large part of the lard is sent to those two countries. During the period 1894–1898 the United Kingdom annually took about 194,000,000 pounds on the average, the value being about $13,000,000. Germany took during the same period about 144,000,000 pounds, valued at $9,000,000. The United Kingdom's proportion of our total lard exports was 36 per cent and Germany's 27 per cent. We also shipped considerable lard to the Netherlands and Belgium. The average yearly shipment to the Netherlands was about 45,000,000 pounds, with a value of $3,000,000; that to Belgium was about 33,000,000 pounds, valued at about $2,000,000. The Netherlands took about 8 per cent and Belgium about 6 per cent of the total. Among other countries to which we shipped in lesser quantities were Cuba, France, Brazil, and Denmark.

Q. (By Senator KYLE.) What percentage did France take?—A. France took about 5 per cent.

FRANCE AS A MARKET.

Q. In your list of destinations you mention England, Germany, Belgium, and the Netherlands, and seldom ever include France among them. What is the reason that France consumes such a small proportion of American products? Do they produce largely in all these lines?—A. France, of course, is to a very large extent an agricultural nation, producing from its own soil an abundant food supply, and so we have always found it difficult to market our agricultural products there. The difficulty is increased by rather stringent tariff legislation enacted in the interests of French agriculture. I think there is also, to a certain extent, a prejudice in France, as in Germany, against some American products, especially meat products. At any rate, it has been the history of the trade that the French have not taken their proportion of our meat products.

Q. Not even considering the question of obstruction?—A. I think not.

HOGS.

Q. You bring in the hog before you get through, do you not? I would like to have that next to the lard; the hog is a very important institution in this country.—A. The hog is certainly a very important institution in this country, but it is not sent out alive to any considerable extent.

Q. Goes as pork, of course?—A. It goes in the form of pork; the packing is done here. Our average annual exports of live hogs during the five years 1894–1898 amounted to only about 14,500 in number; the value was about $144,000. They went chiefly over our borders to Mexico and Canada. We sent an average of about 10,000 head to Mexico, valued at about $115,000; and to Canada about 2,000 head, valued at about $11,000. We also exported an average of nearly 2,000

head to the Hawaiian Islands, the value being about $10,000. Of the total number of hogs exported, Mexico received 67 per cent, Canada 15 per cent, and the Hawaiian Islands 13 per cent.

FRESH PORK.

Our exports of fresh pork averaged only a little over 3,000,000 pounds a year, and went chiefly to the United Kingdom, the shipments to other countries being inconsiderable. The total value was about $220,000.

SALTED OR PICKLED PORK.

Of pork, salted or pickled, we exported about 70,000,000 pounds a year, the value being about $4,000,000. Of this product the United Kingdom took 22 per cent, the amount being about 15,000,000 pounds and the value about $1,000,000. The remaining exports of salted or pickled pork went chiefly to Haiti, Canada, British West Indies, Porto Rico, British Guiana, and Germany.

Q. Germany comes last in the list in regard to importance?—A. I have named only the most important countries; there are many other countries, of course, of lesser importance.

Q. Is Germany named in the order of importance?—A. Yes; they were all named in the order of importance.

Q. Germany tailing the list?—A. Germany took a little over 3,000,000 pounds a year during that period, the value being about $200,000. Germany's share was less than 5 per cent of the total.

BACON.

Of bacon we exported annually about 490,000,000 pounds on an average, and the value was about $38,000,000. The United Kingdom took of this amount about 77 per cent, or 377,000,000 pounds, valued at $30,000,000. We sent 31,000,000 pounds, or about 6 per cent, to Belgium, the value being $2,300,000; to Germany we sent about 5 per cent, or 23,000,000 pounds, worth $1,500,000. We shipped about 16,000,000 pounds to Brazil, or slightly more that 3 per cent, the value being $1,200,000. The Netherlands took about 2 per cent, or 11,000,000 pounds, valued at $800,000. These five countries were the leading destinations.

HAMS.

Of hams we exported about 137,000,000 pounds a year, the value amounting to about $13,700,000. The United Kingdom took 111,000,000 pounds, valued at $11,000,000, this being 81 per cent of the total. After the United Kingdom, Belgium was the most important market, taking about 8,800,000 pounds, valued at $860,000, or about 6 per cent. We shipped about 4,000,000 pounds a year to Cuba, the value being $435,000; Cuba took about 3 per cent of the total. To Germany

we also sent about 4,000,000 pounds, or 3 per cent, the value being $383,000. To Canada we sent about 2 per cent, or 3,000,000 pounds, worth $292,000. The only other country that took hams to the extent of 1,000,000 pounds a year was the Netherlands, the shipments to that country averaging about 1,400,000 pounds, or slightly more than 1 per cent of the total, the value being about $147,000.

OIL CAKE.

Another item I mentioned as being of interest because of the rapid growth of its exportation was oil cake and oil-cake meal. The exports are recorded under two heads, oil cake and oil-cake meal made from cotton seed and that made from flaxseed or linseed.

As to the cotton-seed oil cake or oil-cake meal, we shipped of this product annually during 1895–1898 about 609,000,000 pounds on an average, the value being about $5,400,000. It was sent chiefly to Germany and the United Kingdom, the former country taking about 47 per cent of the total, or 289,000,000 pounds, valued at about $2,600,000, and the latter country, the United Kingdom, about 27 per cent, or 165,000,000 pounds, valued at $1,400,000. After these two countries the most important market was Denmark, which took on an average about 11 per cent of the total, or 66,000,000 pounds, worth $585,000. To the Netherlands we sent 57,000,000 pounds, worth $518,000, or about 9 per cent; to Belgium 17,000,000 pounds, worth $150,000, or about 3 per cent; and to France 12,000,000 pounds, worth $100,000, or about 2 per cent. The shipments to other countries were comparatively unimportant.

Now, taking up flaxseed oil cake and oil-cake meal, we sent of this product to foreign markets about 377,000,000 pounds, the value being close to $4,000,000. The United Kingdom received about 48 per cent, or 181,000,000 pounds, valued at nearly $2,000,000; Belgium about 26 per cent, or 98,000,000 pounds, valued at $1,000,000; the Netherlands about 14 per cent, or 54,000,000 pounds, worth $571,000; and France 5 per cent, or 17,000,000 pounds, valued at $172,000. To Germany we shipped 12,000,000 pounds, or about 3 per cent, the value being $126,000. We also sent about 3 per cent to the British West Indies, which took 11,700,000 pounds, worth $136,000. These were the most important markets for flaxseed oil cake and oil-cake meal.

COTTON-SEED OIL.

I also mentioned cotton-seed oil, stating that the exports of this product amounted to about $12,000,000 in value for the year 1899. The average for the five years 1894–1898 was about $7,000,000 in value, and in quantity about 25,000,000 gallons. Of these exports, we sent to France 6,700,000 gallons, worth $1,800,000, or about 27 per cent of the total.

Q. (By Mr. KENNEDY.) There must have been a remarkable growth in the exportation of cotton-seed oil; for the year 1899 you say it was $12,000,000, while the average for the five years 1894–1898 was 7,000,000. Where did the increase come; all along, or was it remarkble for any one or two years?—A. There was a marked increase in 898 and 1899. There was a considerable increase in the preceding ears, but in the last two years there was a very decided increase. he quantity exported increased from 27,000,000 gallons in 1897 to 0,000,000 gallons in 1898 and to 51,000,000 gallons in 1899.

Next to France in importance as a market for cotton-seed oil comes he Netherlands, to which country we exported during 1894–1898 an verage of about 5,800,000 gallons a year, or about 23 per cent, the alue being nearly $1,800,000. After France and the Netherlands, hich took over half of the total, the principal markets were the Jnited Kingdom, Germany, Austria-Hungary, Mexico, and Italy. We sent to the United Kingdom about 9 per cent, or 2,200,000 gallons, worth $595,000; to Germany about 8 per cent, or 2,000,000 gallons, worth $648,000; to Austria-Hungary also about 8 per cent, or nearly 2,000,000 gallons, worth $572,000; to Mexico about 6 per cent, or 1,500,000 gallons, worth $336,000; and to Italy about 5 per cent, or 1,300,000 gallons, worth $382,000. These were the only countries to which we sent average annual exports exceeding 1,000,000 gallons.

OLEO OIL.

Another product for which I will give statistics of distribution is oleo oil. Our exports of oleo oil for the five years 1894–1898 averaged about 110,000,000 pounds, and the value about $8,357,000.

Q. (By Senator KYLE.) What was the average exportation of butter during these years, and also give the valuation.—A. The average exportation of butter was 18,764,000 pounds and the value about $2,858,000.

Q. As against 110,000,000 pounds of oleo oil?—A. Yes. Of these exports of oleo oil, the Netherlands took about 60 per cent, the average quantity being about 66,000,000 pounds and the value about $5,000,000. Germany was the second market in importance, taking 23 per cent of the total, or about 25,000,000 pounds, with a value of about $1,900,000. Our exports to the United Kingdom, which ranked third as a market, averaged 8,000,000 pounds, or about 7 per cent, the value being $645,000. To Sweden and Norway we sent about 4 per cent, or 4,320,000 pounds, worth $300,000, and to Denmark about 3 per cent, or nearly 3,000,000 pounds, worth $233,000. Belgium took slightly more than 1 per cent, or 1,400,000 pounds, the value being $110,000. Shipments to other destinations were comparatively small.

The oleo oil exported to the Netherlands is used chiefly for manufacturing oleomargarine, or imitation butter, which forms an extremely

important industry there. In some of the other countries I have mentioned our oleo oil is used quite extensively for the same purpose.

EXPORTS OF DAIRY PRODUCTS.

DECREASE OF AMERICAN BUTTER EXPORTS.

Q. (By Mr. A. L. HARRIS.) You may state, if you can, what effect this increase in the export of oleo oil had on the dairy interests of the country.—A. I was about to refer to the exportation of the dairy products, butter and cheese, as presenting the most striking example of decline in our agricultural export trade. I have tried to cover some of the most important instances of increase in the products I have already mentioned. Butter and cheese present the most striking cases of loss, and to illustrate the falling off that has occurred I wish to give a few figures from our export records. Going back to 1880 we find that there was an annual export of nearly 40,000,000 pounds of butter. I will give the exact figures, which are 39,237,000 pounds, valued at $6,691,000. That year represented about the height of our export trade in butter. In 1890 the exports were 29,748,000 pounds, valued at $4,187,000, a decline of nearly 10,000,000 pounds for the decade. In 1895 our exports had dropped as low as 5,599,000 pounds, valued at $916,000. That was about the low-water mark in our butter export trade. For the last two or three years the trade has been picking up a little. In 1899 we exported about 20,248,000 pounds, worth $3,264,000.

Q. (By Senator KYLE.) Still very much less than in 1890?—A. Only about one-half what we exported twenty years ago.

CAUSES OF DECREASE OF AMERICAN BUTTER EXPORTS.

Q. (By Mr. A. L. HARRIS.) Is that quantity accounted for solely on account of the increase of the export of oleo oil?—A. No.

Q. To what other cause can you attribute that falling off?—A. Of course the increase in the production of imitation butter and its increased consumption abroad have naturally affected the consumption of butter, but they have not caused this great falling off in our export trade. In spite of the increased consumption of butter substitutes there has been an increased exportation of butter from most of the dairy countries. They have increased their trade while ours has been dropping off. The chief cause of this decline is found in the unfortunate management of our export trade. The chief cause of the decline was the inferior grade of butter that our exporters sent to foreign markets, and especially to the United Kingdom, which is our chief butter market. After we had established a trade of considerable importance and created a fair reputation for our butter in the foreign market, unscrupulous exporters began to take advantage of the situ-

tion to dispose of inferior butter, and the lack of any Government inspection of export butter in this country made it possible for them to ship almost any kind of butter. What I suppose you might call adulterated butter—process butter—renovated butter—they were able to label as they pleased, and large quantities began to be sent to the English markets, and this naturally brought the American butter as a whole into disrepute. I should have said in the first place that as a rule we did not send our best butters to the British market; inferior grades that could not be readily disposed of in our domestic market were sent abroad in large quantities, and it is generally admitted that this was the cause of the loss of our export trade in butter.

Q. Any recent tariff discriminations, or anything of that kind?—A. No. Our chief market, you see, is the United Kingdom, where butter is admitted free of duty.

INCREASE OF DANISH BUTTER EXPORTS.

In contrast to this decline in our own export butter trade was the experience of certain other butter-exporting countries, and especially Denmark. In 1880, the first year I referred to as regards our own exportations, the Kingdom of Denmark exported about 27,498,000 pounds of butter, having a value of about $6,305,000. By 1890 the Danish exports had increased to 98,373,000 pounds, worth $20,808,000. In 1898, the last year for which we have their export returns, Denmark exported 160,143,000 pounds, worth $34,576,000.

Q. Where did Denmark find the market chiefly?—A. Denmark sends her butter almost exclusively to the British market—the greatest butter market of the world. Denmark caters to that market, and makes her butter with a special reference to its requirements. Only a very small per cent of Danish butter goes to other destinations.

Q. What percentage of the oleo oil does Denmark take?—A. About 3 per cent.

Q. Our people, then, have discredited their own product?—A. Exactly.

GOVERNMENT SUPERVISION IN DENMARK.

The butter export trade of Denmark is practically under Government supervision. It has been the policy of the Danish Government, first of all, to establish a reputation for its products in foreign markets, and then to compel its producers and exporters to maintain the high standard of those products.

Q. Please state how they succeed in enforcing that requirement. Do they have inspections at the borders?—A. Yes; the butter for export is carefully inspected, under the direction of the Royal Agricultural Society, acting for the Government, and no butter is allowed to go out of Denmark that does not come up to the required standard. It is a remarkable fact that Danish export butter is all of one grade.

The importers in England simply give an order for so much "Danish butter" at the market quotation. This fact speaks volumes for the character of the product that is shipped from Denmark.

Q. (By Senator KYLE.) Very similar to our buying the Elgin butter in this country, is it not?—A. Somewhat similar to that, perhaps.

VALUE OF GOVERNMENT CERTIFICATE.

Q. Elgin creamery butter—people know what that means when they ask for it and pay for it?—A. Yes; but in the case of Danish exported butter the British purchaser practically has a Government guaranty that the butter will be of a certain grade and up to a certain standard.

Q. What have you to say in reference to the United States inspection?—A. We do not have any such thing as regards export butter, and that is the great difficulty; that is exactly what we need. I believe we should have a system of Government inspection for dairy products similar to that applied to our meat exports; and, in fact, our Secretary of Agriculture, Mr. Wilson, in his last annual report recommended that such a system be established, requiring our export butter to be inspected and labeled as to grade and sent abroad with the Government certificate upon it, guaranteeing to the foreign purchaser that the butter is of the grade claimed by the exporter, and thus preventing the fraud now possible in the exportation of this product.

Q. And that it is butter and not oleomargarine?—A. Certainly.

Q. It would be a very good thing if we could get the same guaranty for the American consumer?—A. Yes.

INCREASE OF BUTTER EXPORTS FROM CANADA.

In Canada they are adopting a policy very similar to that in vogue in Denmark.

Q. (By Mr. KENNEDY.) Where does the Canadian butter go?—A. It also goes chiefly to England.

Q. (By Mr. FARQUHAR.) How many years is it since Canadian butter and cheese have run American butter and cheese out of the English market?—A. I spoke of 1880 as being within the period of our greatest development in the butter trade.

Q. That was the high-water mark?—A. As regards butter, yes. I do not refer to Canada as a competitor in the butter export trade especially. It is in the cheese export trade that we have lost to Canada. The Danes have developed the butter export business much more extensively than Canada, although latterly the Canadians are taking steps to push their butter export business, just as they have been doing with the cheese export business.

Q. Can you give figures to show how far the Canadians have come into the United States market with butter product, even as against the tariff?—A. Only to a very small extent. I have not the exact figures here. Their total exports of butter are not large, however, although

hey are now beginning to develop. In 1899 Canada exported to all lestinations about 20,000,000 pounds of butter, the value being about $3,700,000. In 1890 very little export business was done, less than ,000,000 pounds going abroad. The Canadian trade fell off at about he same time as that of the United States.

Q. And fell off for the same reason?—A. Presumably the same, although I have not looked into that matter so carefully.

I will quote now the 1880 figures for Canada. In that year Canada exported 18,535,000 pounds of butter, worth about $3,000,000. In 1890, as I have said, the shipments dropped to less than 2,000,000 pounds, the value being only $340,000. In 1899, under the measures taken to reestablish the butter export business, the amount shipped came up to about 20,000,000 pounds. In other words, the Canadians export about as much now as in 1880. That is the history of their trade. Their efforts to push the butter export business are comparatively recent, much more so than their efforts to push the cheese export trade. They are now taking measures similar to the Danish methods to put their butter into the British market, and that is one reason why it is very important for us to take some such measures.

(At this point the commission took a recess until 2 o'clock, and requested Mr. Hitchcock to continue his testimony at 10 a. m. Friday, June 15, 1900, at which time the hearing was continued as follows:)

SUMMARY OF PRECEDING TESTIMONY.

Q. (By Mr. A. L. HARRIS.) Professor, the other day you were testifying in regard to the decline of dairy products. Have you anything more to say in regard to the cause of the decline in dairy products?—A. I called attention to the fact that there was a very remarkable falling off in our exports of butter, beginning soon after 1880, when the trade had reached its high-water mark. I explained that this decline was largely due to the shipment of an inferior and in some cases an adulterated product. In contrast to the falling off in our own export trade in butter I mentioned the remarkable development of the export trade of Denmark, where it has been the policy to permit the shipment of no inferior products. The Danes started in to establish a reputation for their butter, and, having established it, they took measures to maintain it, and the result has been the remarkable growth of trade that I set forth statistically. I also mentioned the fact that Canada has recently taken measures to extend her export trade in butter, and with marked success.

INCREASE OF BUTTER EXPORTS FROM AUSTRALASIA.

I wish also to mention the case of the Australasian colonies of Great Britain. The butter exports from these colonies to the United Kingdom, which is their chief market, increased from less than 4,000,000

pounds in 1889 to over 40,000,000 pounds in 1899. In Australasia measures similar to those carried out in Denmark have been adopted, and results almost as notable in the way of increased trade have followed.

INCREASE OF BUTTER EXPORTS FROM OTHER COUNTRIES.

Other countries that have developed an important export trade in butter within the last decade are Sweden and Finland. These countries produce a butter that is practically the same as Danish butter, and they are shipping it now to the British market in increasing quantities each year. I should explain that quite a large quantity of this butter from Sweden and Finland has hitherto gone to Denmark, being practically the same thing as Danish butter, and a considerable portion of it has undoubtedly been reexported by the Danes as their own butter, with which it is to all practical purposes identical. Even Russia is also beginning to develop an export trade in butter. The Baltic provinces, especially, are giving their attention to this industry, and are taking active measures to develop it—measures similar to those taken by Denmark. The Russians are engaging Danish experts to install their creameries and to instruct their butter makers. Already they are beginning to ship a high grade of butter, some of which is sent to the British market, and finds there a ready sale.

These various countries, none of which has greater dairying possibilities than the United States, are thus developing and widening their export trade in this commodity, while we, because of our unbusinesslike methods, have been losing the little export business that we formerly possessed. I believe that this product as a factor in our export trade should receive special attention. I think it would be profitable to take measures to develop an export trade in butter.

RECOMMENDATION OF INSPECTION.

Q. Could that be best accomplished by legislation, or do you think voluntary associations could bring about the result?—A. I think that legislative aid would be of great assistance. I am strongly in favor of official inspection of exported butter. I think that is the most feasible plan for preventing the shipment of inferior produce.

Q. You would recommend an inspection similar to that that is now required for our meat products?—A. Yes; the same system could be extended so as to include butter and other dairy produce. As I stated at the last hearing, the Secretary of Agriculture has made the recommendation that butter and cheese and milk for export be subjected to an official inspection, that a grade be established, and that produce that comes up to that grade be certified to by the Government inspector, labeled, and the Government certificate placed upon it as a guaranty to the foreign importer of its quality. Such a measure is very strongly recommended by the Department, and I think that it would meet with

the approval of the dairying industry. Some inquiries have been made in this regard and the general feeling, as far as tested, seems to be in favor of Government inspection for these products.

DANISH METHODS WITH BUTTER.

Q. (By Mr. FARQUHAR.) Are you through with the butter?—A. Not fully.

Q. Has the Department of Agriculture made any investigation as to the process of manufacturing butter in Denmark and Sweden in comparison with America and Canada?—A. Yes.

Q. Have you any sufficient, obtainable reports to show the difference in the quality of the milk and cream that enters into the manufacture of the butter?—A. Several years ago the Department sent a special agent to Denmark to investigate the dairying industry. The agent was commissioned toward the close of Secretary Rusk's administration, as I remember. He went to Denmark and spent several months there investigating the dairy methods, and afterwards made a very thorough and comprehensive report, which was published in the last Administration. The Department has not made similar investigations in the other countries you have mentioned.

Q. Was the Denmark manufacture at that time as far progressed as it is now, as perfect?—A. Probably not as perfect, because the Danes are perfecting their system every year, but it had reached a condition that made it rank as the foremost in the world. The Danes are regarded as the pioneers to a certain extent in butter production by modern methods. They have been the models, not only as regards production, but as regards export methods, for these various other countries I have mentioned—these countries that are now developing very rapidly an export trade in butter.

Q. Do you know whether the Danish butter is made from the sour cream or just simply from the milk after having extracted the cream from it, what we call the body of the milk?—A. I am not an expert in the dairy business, but I understand that the Danish butter is made almost altogether from pasteurized cream; a very large percentage of the Danish butter is pasteurized, and to that fact is attributed its remarkable uniformity.

Q. In other words, it is a cream butter?—A. Oh, yes; it is a cream butter.

OPPORTUNITY FOR INCREASING AMERICAN BUTTER EXPORTS.

Q. Is it possible under any inspection for the American butter to compete with the cream butter of Europe? Has the Department discovered that, or has it gone into the investigation of it?—A. The Department thinks it is possible for us to put a butter into the British market that is equal in quality to the Danish.

Q. Certainly, provided that they take the same class of cream to

make the butter, but no other way?—A. Of course, it goes without saying that they would have to use an equally good material.

Q. Is it not a fact that you have investigated that really the Americans are putting a butter there that has not the full fatty substance of butter and is not perhaps equal to the cream butter of Europe, to the English, Scotch, Irish, or Danish?—A. In the past that was the great difficulty with our export trade. Our butter was often of an inferior quality. That can not be denied.

Q. Inspection would not improve it?—A. Inspection would not improve the inferior butter, but the idea, as I understand it, is to establish a high grade. Butter that reaches that grade will carry a certificate. Inferior butter will go without a certificate. The foreign importer, knowing that we are certifying to the grade of high-class butter, will naturally demand butter bearing such certificate. The inferior butters will therefore be at a great disadvantage. At present they are not at such a disadvantage, for the reason that neither the inferior nor the best butter bears any distinctive label or anything to guarantee that one is inferior and the other high grade.

UNIFORM QUALITY OF DANISH BUTTER.

Q. All the Danish butter is labeled in the London market?—A. All the Danish butter that is exported is of a certain grade, a high-grade butter. It is called Danish butter; it is purchased in England simply as Danish butter. The English buyer merely orders so many pounds or casks of Danish butter, and that is the extent of the contract. He pays the price quoted in the market on the day of his purchase.

PRICES OF BUTTER IN ENGLAND.

Q. Are you aware that there is a very wide difference in the price of butters, between the high-grade British and Danish and the ordinary American and Canadian?—A. There is a difference of 3 or 4 cents a pound.

Q. Do you mean pennies or cents?—A. I mean cents; I am quoting in United States money. There is a difference of 3 or 4 cents a pound. The import price in England of Danish butter in 1899 was 23 cents a pound. That was the average import price of all the Danish butter sent into the United Kingdom during the calendar year 1899.

Q. That is what is called 11 pence half-penny a pound, British figures?—A. The price averaged 22.95 cents for the entire year, but the quotation would naturally vary somewhat from day to day.

For the same year, the calendar year 1899, the butter imported into the United Kingdom from the United States averaged 19.2 cents per pound, and the Canadian butter imported into the United Kingdom averaged 19.4 cents per pound. In that year the Canadian brought a rifle more than the United States butter; but you see there is a

difference of nearly 4 cents between the price of the Danish and the United States and Canadian butter.

Q. Is it not also a fact that the Danish butter holds its price in the market almost against any changes, and it is a very high price, while there are fluctuations in the butter that comes from the United States and Canada?—A. The Danish butter is noted because of its uniformity; the high price is uniformly maintained. I do not mean to say that the same price is maintained, but I mean to say that Danish butter has a high price always, as compared with the price of other butter. The Danish butter brings the highest price of any butter imported into the United Kingdom, except the fresh butter. The fresh butter that comes in from Normandy brings a higher price, of course, but that is a peculiar trade. The Normandy butter comes in within twenty-four hours from the churn, and is perfectly fresh. It is unsalted, while the Danish butter, like the other imported butters, is a salted butter.

EXPORTS OF CHEESE FROM THE UNITED STATES AND FROM CANADA.

Q. (By Mr. A. L. HARRIS.) Do the same conditions exist in regard to cheese, substantially, that you have described in regard to butter?—A. In our exportation of cheese we have had practically the same experience as that described for our butter export trade. In 1881 our exports of cheese reached the highest figures ever attained, amounting to 147,996,000 pounds, having a value of $16,380,000. From that time the exports declined. In 1890 they had fallen to 95,376,000 pounds, valued at $8,591,000; and in 1899 they amounted to only 38,199,000 pounds, valued at $3,316,000. During the past twenty years there was a loss of over 100,000,000 pounds in our export trade in cheese, and the reason for this was essentially the same as that given for the decline in our exportation of butter, namely, the shipment of an inferior product, chiefly the shipment in large quantities of so-called filled cheese. Soon after 1880 it became the practice to export filled cheese. This adulterated product was sent abroad in the guise of first-class or full-cream cheese. The result was that the British purchaser very soon discovered that he was being defrauded. The inferior quality of the filled cheese soon became known in the British market and our trade began to fall off. Our export trade in cheese was lost to Canada, where measures were taken to prevent such an experience. The Canadian government not only prevented the manufacture of filled cheese, but took measures to improve the quality of the Canadian product and to secure its ready sale in the British market. They saw an opportunity to establish a trade when that of the United States began to fall off, and they made the most of it, as is shown in a striking manner by their export figures. In 1880 Canada shipped abroad 40,369,000 pounds of cheese, valued at $3,893,000. In 1890 the trade had increased to 94,260,000 pounds, having a value of $9,372,000.

During the past year, 1899, the exports of cheese from Canada reached the enormous total of 189,828,000 pounds, having a value of $16,777,000. In the space of twenty years the Canadians increased their shipments from about 40,000,000 to nearly 190,000,000 pounds.

CAUSE OF INCREASE OF CANADIAN CHEESE EXPORTS.

Q. How do you account for that enormous increase on the part of the Canadian export of cheese?—A. That increase is accounted for very largely by measures taken by the Canadian government to develop the cheese industry and to establish an export trade. The Canadian government began by helping the manufacturers. It gave liberal bonuses for the building of factories and, under the supervision of the ministry of agriculture, established a system of instruction and inspection that brought about a rapid improvement in the methods of cheese production. As the surplus above domestic requirements increased, the government took measures to place that surplus in the foreign market by securing for the exporters favorable transportation facilities. And while I am discussing what has been done by the Canadian government for the cheese export trade, I wish to include also the export trade in butter, because the measures taken by Canada for the shipment of butter and cheese naturally go hand in hand.

INSPECTION OF CHEESE FOR EXPORT.

Q. There is a possibility, then, of having a system of inspection that would insure a pure cheese?—A. The inspection system that I spoke of would be particularly valuable in the case of cheese, for the reason that no filled cheese would go out as honest cheese under the Government certificate. The probability is that after the system of inspection had become introduced the filled cheese exported would be at such a great disadvantage without a certificate that it could not maintain its market as it does now.

Q. Would this inspection be at the factory?—A. The inspection would probably be in part at the factory, just as the meat inspection is in part at the packing house.

DEVELOPMENT OF BUTTER EXPORTS BY CANADA.

I said that the Canadian government has assisted in the establishment of cheese factories by giving liberal bonuses, and I can also say that it has done the same as regards the manufacture of butter. It has not only done that, but it has established a system of cold-storage transportation from the factory or the creamery to the foreign market. The measures for the development of the butter export trade began to be taken in 1895, I think. The Canadian government offered a bonus of $100 to creameries that should install and maintain cold-storage facilities in connection with their creameries. This $100 was to be

paid during a period of three years, $50 the first year, $25 the second, and $25 the third. The government also secured cold-storage facilities upon railroads, so that the butter after being cooled at the creamery would go directly into a refrigerator car for safe transportation to the point of ocean shipment. At the terminal of the railroad the government established a cold-storage warehouse in order that the butter could be safely kept between the time of reaching the railway terminal and the loading upon the ship. The government also secured refrigeration service on steamship lines to the British ports. This cold-storage system was installed according to instructions prepared by the department of agriculture, and, in some cases at least, Parliament defrayed the expense of installation. To give the trade a start, the government contracted with the steamship companies for cold-storage space, put in the necessary refrigerator chambers, and then guaranteed to the steamship company the full freight charges for the service. Under these conditions very favorable transportation rates were procured, and as the initial expense was borne partly by the government, it was possible for the Canadian producers to send their dairy products to the British market at very low rates. In this manner a great inducement to exportation was offered.

The government also watched very carefully the quality of the product shipped, issued instructions as to methods of packing, branding, labeling, etc., and, in fact, practically supervised the entire exportation. Numerous trial shipments were also made by the government, the government purchasing the produce and sending it over and disposing of it through its own agents abroad. I might mention, too, that other than dairy products were shipped experimentally. Canadian fruits, for instance, were sent abroad in trial shipments.

EXPERIMENTAL SHIPMENTS OF BUTTER.

Q. (By Mr. KENNEDY.) Is it your belief that if America is to compete with Canada for this trade in foreign markets we must copy the methods of the Canadian government?—A. I do not think that it will be necessary for us to do what the Canadian government has done as a whole. The Canadian government has gone pretty far in the matter. I believe that if the trade can once be given a fair start and the American producer convinced that there is a profit in it the facilities will be forthcoming. The producers themselves will take the necessary action to get the required transportation facilities. But first of all it is important—it is necessary—to show that there is a possibility of establishing such a trade on a profitable basis. The initial experiments can very properly be made by the Government; and, in fact, they are, in a small way, now being inaugurated. The United States Department of Agriculture, by direction of Secretary Wilson, has been making experimental shipments of butter during the last two or

three years, and with considerable success. We began, in 1897, to send high-grade American butter in small lots to the British market. The Department purchased this butter from leading creameries in several States. In 1897, lots were procured from eleven different States, I believe, such creameries being chosen as had made a favorable reputation for their butter. Under directions from the Department, this butter was put up in the form thought to be best suited to the requirements of the British market, not only as regards quality but as regards packing. The butter preferred in the British market is a mild butter, lighter than ours in color, and with less salt, and the butter sent abroad was so made. It was packed in a variety of packages, experimentally, in order to ascertain, as far as possible, what packages would be most desirable for future use. As a result of the experiments in the first year, the Department adopted for subsequent shipments a cubical box similar to the Australian box, but tapering slightly from top to base, in order to facilitate unpacking the butter. Aside from the taper it is identical in size and shape with the standard Australian box that is in such favor in the British market.

Trial exports have been continued during the past year, some of the shipments going to new destinations. Butter has recently been shipped to the Orient to some extent. Experimental shipments were first sent to London, then to other English cities, and later to Paris. It is, of course, only the beginning of experimentation in this line, but I think I can say that the result has been on the whole highly satisfactory. We have convinced the British butter merchants, to some extent at least, that a high grade of butter can be made in the United States, butter that is equal to the best butters imported from other countries. That, of course, was the chief object of the experiment—to show the British consumer that all American butter was not inferior, but that, on the contrary, we were making here a first-class article. These experimental shipments of butter will probably be extended, and further beneficial results are hoped for.

ARTIFICIAL BUTTER IN EUROPE.

Q. I infer from what you said the other day about the large shipments to the Netherlands of certain ingredients which entered into the manufacture and composition of imitation butter that there must be a large manufacture of imitation butter at certain points in Europe. Can you say where that imitation butter finds a market?—A. The manufacture of oleomargarine, or artificial butter, is carried on most extensively in the Netherlands. The exports from the Netherlands exceed 100,000,000 pounds a year. Of these exports by far the largest part goes to the United Kingdom, while the remainder is distributed quite generally over Europe and also to some extent through tropical countries.

EXTENT OF BRITISH DEMAND FOR BUTTER.

Q. So that there is a demand for that artificial butter in Europe?—A. Artificial butter is used now quite extensively in Europe. It is probably used most extensively in England and Germany, but, although the manufacture of artificial butter has increased very largely, the consumption of real butter has also increased. There is a more general use of butter throughout the world. The poorer classes of the people are beginning to use it much more than formerly, and for that reason the production of oleomargarine has not destroyed the market for butter. The United Kingdom, of course, is the important butter market of the world, and to show you what has been the increase of the demand in that market I will quote some statistics I have on the subject. In 1886, which is the first year for which we can give separate statistics of the imports of butter into the United Kingdom (prior to that year butter substitutes were grouped with butter, oleomargarine being included in the butter imports as recorded; we can not divide them prior to 1886), the imports of butter into the United Kingdom from all sources amounted to about 173,000,000 pounds. In 1899 the imports of butter into the United Kingdom amounted to about 380,000,000 pounds. Thus in a period of fifteen years the demand of the British market for imported butter more than doubled. Practically each one of the past fifteen years has shown a marked increase in the imports of butter into the United Kingdom. The increasing exports from the various countries that I have mentioned as showing rapid development are chiefly due to this growing demand of the British market. Those countries are supplying this demand—they send their butters to Great Britain almost exclusively. It is the great butter market of the world.

LACK OF COLD-STORAGE FACILITIES.

Q. (By Mr. A. L. HARRIS.) In the experiments in shipping that you are making in the Department, do you find the necessary conditions or facilities for cold storage?—A. There are excellent facilities on the railways of the United States. We have probably the best cold-storage transportation facilities by rail of any country, but there is a lack of sufficient accommodations on the ocean steamships. The cold-storage chambers on the steamships plying between the United States and Europe are very largely monopolized by the meat interests. They are contracted for and controlled by the packers. The meat exporters take measures to procure the amount of space required for their trade and the necessary refrigeration facilities, but aside from that industry there is not sufficient cold-storage service, and it has been found difficult at times in our experimental shipments to get the facilities needed. That is one thing, of course, that would have to be remedied. Another

great difficulty is the lack of cold-storage facilities at the docks. One of the chief dangers in shipping butter and other perishable products is that they will arrive at the port of shipment some time in advance of the sailing time and become damaged during the wait. We need cold-storage facilities at the docks, so that products that are brought on the refrigerator cars can be transferred at once into cold storage, awaiting the time when they can be put aboard ship.

Q. Have you anything further on the subject of dairy products?—A. I should like to say that practically the same measures that have been taken by Canada for the development of an export trade in dairy products and in other perishable products have been taken within the last few years by the Australasian colonies.

Q. Do you think it would be advisable for the Government to give some attention to this question of proper facilities for shipment?—A. I do most assuredly think it would be well for the Government to take some measures. I do not know that it would be best for the Government to provide cold-storage and cold transportation facilities, as Canada has done, but I think that the Government can very well in an advisory capacity make recommendations, and I do think that the Government should, first of all, take into its hands the matter of inspection. I think that is the most important measure to be taken, so as to prevent inferior and fraudulent produce going abroad under false colors, as is now possible.

EXPORTS OF GRAIN.

Q. You touched the other day upon the subject of the grain export. Have you anything additional to say in regard to conditions favorable or unfavorable for the exportation of grain?—A. Within the last few years many complaints have been made in foreign ports as regards the condition in which some of our grain arrives. The grains that have been complained of chiefly are indian corn, wheat, rye, and barley. Complaints have been made, as regards indian corn, that in many cases that grain has reached the European port in a damaged condition, caused by sweating. It has been claimed that much moldy grain has come into European ports, and not only that, but to some extent it has been claimed that grain of a grade inferior to that of the certificate upon which it was purchased has been received. As a rule, our grain is sold on the certificates of inspection that are furnished by the boards of trade and chambers of commerce at the ports of shipment in the United States. The foreign importer contracts for the grain on the strength of that certificate, and, under the rules adopted by our commercial bodies that inspect, the certificate is conclusive. The importer who has bought a cargo of grain upon the certificate issued by one of our boards of trade practically has no redress if, to his idea, the grain does not correspond to the grade that is certified to by the inspector.

LACK OF UNIFORM INSPECTION.

It may be that there is some carelessness in the inspection of export grain in the United States, but from what attention I have given to the matter I am inclined to think that the complaints based on the ground of fraud are mostly unfounded. Unfortunately, the methods of inspection in vogue in the United States lack uniformity. Each board of trade or chamber of commerce adopts its own rules of inspection and its own regulations for grading. In most cases the grades are changed somewhat from year to year, following the average condition of the crop, but the changes made at the several ports are not always uniform. The result is that the certificates issued at different ports do not always mean exactly the same thing. Suppose, for instance, an importer buys a cargo of corn shipped from Baltimore and certified to be No. 2 mixed corn, sail grade, and then a little later buys a cargo shipped from Galveston, Tex., bearing the same certified grade, and it so happens that owing to different standards of inspection the one cargo differs somewhat in quality from the other. The importer who has received one certified grade and then, under a similar certificate, receives an inferior quality, not understanding the conditions, would naturally feel that the second consignment fell short of the standard called for by its certificate.

Q. Is it possible to fix a standard grade for all the ports of the United States?—A. I believe that it would be possible.

Q. Have any steps been taken in that direction?—A. Not so far as I am aware.

Q. If so fixed, would it not be much to the benefit of the exporter from this country?—A. I believe that it would be. If we could have a uniform system of grading for all ports of shipment, so that this variation could not arise under proper inspection, I think it would be a great advantage to the export trade.

Q. (By Mr. FARQUHAR.) Do not all the boards of trade in the United States endeavor to conform to the Chicago inspection and grade or the New York inspection and grade in those two markets at fixed prices?—A. In a general way, of course, the great ports are followed, but as a matter of fact they are not followed absolutely. Grain inspection is had, of course, at practically all of the ports. A great deal of grain is now shipped from our Southern ports, such as Galveston, New Orleans, and Newport News, and the commercial organizations that control the inspection there establish their own rules of grading, and these rules sometimes differ slightly from those in force at New York and Chicago. We made inquiries recently in regard to that very matter, and from the replies received at the Department it is evident that there is, in a number of cases, an appreciable difference between the grades established in a given year at the several ports.

Q. You are speaking of the changes that occur there in grading.

Do not these changes nearly always—in 90 per cent of the cases—occur through the difference of the character of the crops of the season?—A. Where changes are made they are supposed to be based upon that very thing.

Q. It is not an arbitrary thing on the part of the inspector of the board of trade at all, but it is simply that the very grain that comes out of the very section in one year will be graded possibly below or above what it was the year before?—A. Exactly. The grades are based, of course, on the average crop; but the changes in the average crop are not followed as carefully in some ports as in others. We had replies from some ports indicating that the grades established there remain practically the same from year to year.

Q. They do on winter wheat, for instance; they hardly ever change. But will you not find always a great many changes there in the spring wheat because the climatic changes are so much different?—A. The changes in grading are most noticeable in corn, of course. I do not think that the changes in wheat are so marked as the changes in corn. It has been chiefly the corn against which these complaints have been made on the ground of grading.

INSPECTION CERTIFICATE.

You spoke of the official certification.[1] Now, that is another matter that I am glad you have suggested, for it has caused a great deal of misapprehension abroad. The certificates issued by our boards of trade and chambers of commerce usually bear the inscription, "Official inspection certificate." The importers abroad quite generally understand that to mean official as applying to the Government. I find abroad a general impression that our certificates are Government certificates.

Q. And yet, practically, they are just as good as Government certificates, are they not?—A. Well, that is a question.

Q. Well, did you ever find a board of trade that did not select the very best men that could be found there as inspectors? Merit and not favoritism rules in every case of that kind, considering the millions of money that are involved in the exchanges and boards of trade.—A. That is a very general question. I am not criticising our inspection system as a whole, because I think it is a remarkably good one under the circumstances, considering the vast extent of the country, the different conditions that prevail in the different sections, and the wide distances between the various ports. I think that on the whole the system is an admirable one.

QUESTION OF GOVERNMENT CONTROL OF INSPECTION.

Q. (By Mr. A. L. HARRIS.) Well, owing to the immense quantities of grain and the immense interests that are involved, would it not be

[1] [The interrogatory preceding this response was omitted from the published report of testimony.]

better to have the Government fix the grades and have some means to protect against frauds in mixing, etc., and in bills of lading, owing to the fact that it is discredited? That is, would it not be more satisfactory both to the shipper and to the commission man to know that the inspector was under the control of the Government?—A. I believe that it would be a great advantage to the trade if some steps were taken to secure uniformity.

Q. (By Mr. FARQUHAR.) Why would it not do for the Government to license these inspectors? That would be the way to regulate it.—A. That would be one way, of course. I do not mean to say that the Government should take the matter entirely into its own hands. I am not prepared to say that that is at present necessary, but I think it might be well to place the inspection under the general supervision of the Government, so that uniform rules could be enforced. To establish an official inspection service for grain at all our ports would be quite an undertaking, and I question the immediate necessity of going so far as that.

Q. Why should it not be done in the case of cereals and everything of that kind just as we have in the Bureau of Animal Industry now in the case of animals, meats, and live cattle? Why is there not just as much necessity to inspect the one as the other, and why is there not just as much necessity for official inspection?—A. I am not prepared to say that it would not be a good thing. I have not reached a conclusion in my own mind as to whether it would be advisable at present for the Government to take over entirely to its own control the inspection of export grain. It is, of course, a very comprehensive system. It might be well for the Government to begin by establishing an official inspection that would be optional with the exporter. Argentina has recently done that very thing. The Argentine Government has established an inspection service for grain at its several ports, so that exporters, by paying a small fee, can have their grain officially inspected and obtain an official certificate as to its grade. The Argentine inspection is entirely optional, and it seems to me that in introducing an official inspection of export grain in the United States it would be best at the outset to make it optional rather than compulsory. I believe the advantages of the Government certificate would soon lead to its being demanded by foreign buyers.

Q. (By Mr. A. L. HARRIS.) Would the shipper or commission man object?—A. There would undoubtedly be considerable opposition to a compulsory official inspection. It is very natural to expect some opposition to such a step by the Government. There would probably be opposition on the part of those very organizations that are now controlling the inspection.

Q. Is it not almost as important as the inspection of meat?—A. I hardly think it would do to say that it is almost as important. No; I do not think that there is such a crying need for Government inspec-

tion as there was in the case of meat. There are not the same sanitary reasons for it.

Q. In other words, complaint has not become so common?—A. It has not, because the present grain-inspection system is already a fairly good one, although far from perfect.

Q. Well, would it not be an assurance to the foreign importer when he buys a cargo to know that the grade is the same without regard to the port from which it was shipped?—A. Undoubtedly.

Q. In other words, is not this the tendency now: If they find that the port at Galveston has a lower grade for low grades that go to that port for shipment, would it not generally have a tendency to discredit the grades of the whole country when they pay little attention to what section of the country the grade is shipped from?—A. It would very naturally do so.

ADVANTAGES OF GOVERNMENT INSPECTION.

Q. (By Mr. FARQUHAR.) Would not the establishment of Government inspection make a uniform grade all over the country—naturally tend to?—A. It should do so.

Q. And would it not give a better price for our cereals in Europe if they had the Government certificate back of them, and not that of an individual nor a corporation nor a board of trade?—A. I think that it would.

Q. (By Mr. A. L. HARRIS.) Even if it did not give a better price it would give satisfaction to the people who are buying it now?—A. I should hesitate slightly on the ground of feasibility just now. To my mind it is a question whether it would not be better to extend the system of compulsory Government inspection more gradually. Take, for instance, the dairy products, and first put that branch of the export trade on a satisfactory basis. In other words, introduce these reforms by degrees.

LACK OF INFORMATION ABOUT INSPECTION CHANGES.

I want to say that of course the representatives in this country of foreign importers of grain are supposed to notify the importers whom they represent of any changes in the grading, and to give them exact information on that point, but it often happens that this is not properly done. The boards of trade themselves do not inform foreign importers of the changes. That is left to the representatives in this country of the importers, and there is often laxity about sending the proper information—at least so I have been informed on the other side.

DAMAGE TO GRAIN DURING VOYAGE.

In speaking of the damaged condition of the grain that arrived in urope, I did not mean to imply that it was exported in such condition. y own belief is that a very large part of the damage occurs on the

voyage. In other words, I think that in many cases where cargoes are complained of in foreign ports the grain when shipped from the United States was in proper condition.

UNFAIR COMPLAINTS INFREQUENT.

Q. (By Mr. KENNEDY.) We frequently hear of commission merchants informing shippers of produce that their stuff was received in a damaged condition, and that it is done for the purpose of cheating the farmer, the fact being that the produce more often is in excellent condition when received, but reported in a damaged condition. Is it probable that anything of that practice prevails on the other side in regard to our grains?—A. I have no doubt that there are unscrupulous people abroad, as there are all over the world, who will in some cases make unfair complaints of that kind, but I think as a rule that such cases are rare.

CARELESSNESS IN SHIPPING CORN.

Q. Is it more difficult to ship shelled corn than it is to ship wheat in bulk?—A. It is more difficult. The corn gets out of condition more readily than the other grains, because its moisture content is greater. It is in the case of corn that most of the complaints have been made. Sometimes, when corn in otherwise perfect condition is loaded here in hot weather, the heat it has absorbed causes the grain to sweat and become moldy before it reaches the other side, and then the purchaser there naturally wonders whether that corn was in good condition when it was shipped. I believe, as I said before, that it is on the voyage that most of the damage is done. Much of the damage undoubtedly occurs in the case of bulk cargoes carried by tramp steamers. There are comparatively few complaints against corn carried by the regular liners, for as a rule the regular liners give greater attention to ventilation, and in fact to the care of the cargo generally. Ventilation is a very important factor in the shipment of corn. When shippers load corn into a steamer at a Southern port in hot weather, then batten down the hatches and without any ventilation at all attempt to carry that cargo across the ocean, the chances are very strong that under such conditions some sweating will occur.

CORN LOADED IN IRON STEAMERS.

Corn is sometimes loaded into iron steamers without any protection against the heated iron sides. There should be some kind of a protection—either a board sheathing or a protection of bagging—against the iron sides of the steamer, for as she lies in port her sides above the water line naturally become very much heated by the sun, and when the corn is poured in and lies right up against these hot sides it is not strange that the contact with such heat causes it to sweat.

CORN STOWED IN COAL BUNKERS.

Then, too, corn is sometimes loaded into bunkers that are intended primarily for coal. Quite frequently on tramp steamers where they take a full cargo they load corn into one of the coal bunkers, which are, of course, amidships, and adjacent to the boilers. It is in these bunkers that I think much of the damage is done. The heat from the furnaces and boilers during the passage gradually works its way through the bulkhead, and it is not uncommon, where corn has been loaded in a bunker, to find it badly sweated, especially along the side of the bulkhead that separates the bunker from the boiler space. There the corn is often greatly damaged. It is a question whether corn should be loaded in bunkers at all, owing to the great risk that is taken, or at any rate, whether there should not be some conditions attached as regards sheathing and ventilation.

IMPORTANCE OF VENTILATION DURING VOYAGE.

Even in the ordinary holds, remote from the boilers, unless ventilation is had, corn is apt to become heated at the top of the holds, more particularly during hot weather, because of the heat of the sun on the deck. That could undoubtedly be prevented by proper ventilation. The trouble with the tramp steamers is that they frequently go short-handed, and do not have a sufficient force of men to attend to the ventilation properly. It is possible in fair weather to lift the hatches and let air into the holds where the corn is stowed, but that is often neglected. From my investigations I believe that if proper ventilation were provided a great deal of the damage that now results could be avoided. I understand that the steamers plying from Argentine ports carrying Argentine corn to Europe are now very generally equipped with ventilation facilities. That is a long voyage, and they have discovered the importance of ventilation; but it is unquestionably a fact that a great deal of the corn shipped from the United States is not properly attended to en route.

IMPORTANCE OF CLEANING CORN BEFORE SHIPMENT.

There has also been quite a general complaint against our corn abroad on the ground that it is too dirty. The foreigners say that in this regard it does not compare favorably with the corn shipped from other countries. They seem to think we are more careless, and that we take less pains to clean our corn than is the case in some other countries. It can not be denied that the corn frequently has a good deal of dirt in it, such as broken grains, pieces of cob, etc. When this occurs the danger of sweating is very much increased. The dirt fills in the interstices between the grains, thus excluding the air, and under such conditions heating naturally occurs much more readily. If the

corn were cleaned more carefully before being exported there is no doubt that a great deal of loss would be prevented.

A few weeks ago I received a sample of some foreign materials that were discovered in a cargo of corn shipped from the port of Galveston, Tex., to the Free Port of Copenhagen. Mr. C. D. Hage, the director of the Copenhagen Free Port Company, forwarded to me a box containing quite a variety of metallic articles, including spikes, nails, bolts, screws, pieces of wire, foundry drippings, etc., and also other matters such as glass, pebbles, and the like, that were sent over there in a cargo of corn. [Producing photograph.] I had this material photographed, and I will hand you the photograph that you may see. The articles are shown at one-half their natural size.

DANGER TO MILLS FROM TRASH IN CORN.

Q. (By Mr. A. L. HARRIS.) Is there not danger of our grain being discredited the same as butter has been heretofore?—A. Such cases as this, of course, work very materially to the detriment of our export trade. The seriousness of this particular case will be better understood when I say that, supposing that the corn had been cleaned, the company there did not subject it to any screening, and it went out over the Kingdom of Denmark, carrying this material with it, and these nails and spikes, etc., got into the mills. If you will examine that photograph carefully, you will see that some of the spikes have been between the mill rollers and were flattened out. They did great damage to the milling machinery. The millers are holding the company liable for the damages, Mr. Hage writes me.

Q. (By Mr. KENNEDY.) That is taken from one cargo?—A. This was sent to me as a sample of material that was taken from corn sent from Galveston in one cargo. Part of that material was sent in to the company at Copenhagen by the millers.

GRADING OF EXPORT CORN AS REGARDS CLEANNESS.

This case shows that there is undoubtedly some carelessness. The foreign importers claim that the corn shipped as No. 2 sail grade should be much cleaner than a large part of it proves to be. The contract calls for a grain that is reasonably clean, and they naturally hold that that condition is not carried out in a case of this kind.

Q. (By Mr. FARQUHAR.) You do not know what the grade of this corn was when it was shipped?—A. I am sorry to say that in writing to me about the circumstances of this shipment Mr. Hage failed to state the grade that was certified to; but I have inferred that it was No. 2 sail grade, for several reasons: first, because that is the grade that is generally shipped to Copenhagen; and, secondly, because if it had not been supposedly a reasonably clean corn, the company there would probably have put it through their own screening apparatus.

That is, they would not have been justified in sending out an unclean grade of corn to their customers, and they would not have taken the risk of doing so. But I am sorry to say that Mr. Hage did not state that fact specifically in his letter, and I have not had time to ascertain.

SOURCE OF TRASH IN CORN.

It is a question where this foreign matter came from—where it got into the corn. I presume that this corn may have been simply blown without being screened; however, I do not know as to that. Some of this material was probably shoveled up with the corn when it was put into the shellers. Shellers are sometimes stationed out in the open field. The farmers bring up the corn in their wagons and dump it on the ground in piles, and then it is shoveled from the ground into the shellers. Foreign objects of a less size than the cobs readily pass through the shellers, and these objects would remain in the corn unless it were screened. It would appear, also, that the railway cars in which the grain was carried to the port furnished some of the refuse material. The cars are not always properly cleaned before the grain is loaded. The terminal warehouse or elevator may also have been at fault in this regard.

I want to say in reference to this case that affidavits were presented showing that the steamer had been carefully inspected before the cargo was received, as is the custom. The captain of the steamer made affidavit that the holds in which this corn was loaded were carefully inspected and were free from all foreign matter and in proper condition to receive the cargo. He had a certificate to that effect to show that this matter did not get into the cargo from the ship.

SHIPMENTS OF WHEAT, RYE, AND BARLEY.

Q. (By Mr. A. L. HARRIS.) Are you through with what you desired to say on the subject of grain?—A. I spoke also of wheat, rye, and barley. I will just touch upon these.

Against our wheat complaint has been made abroad that it sometimes contains many unsound and burnt grains, more than would be warranted by the certificate of inspection, and also that it is sometimes deficient in weight. Recently a complaint came to the Department from abroad alleging that some wheat had been received that did not come up to the weight called for in the contract by several pounds per bushel. I also have in mind a complaint made some months ago regarding a parcel of wheat that contained garlic to such an extent that it was necessary to reclean the entire lot before it could go into the mills. Some of the grain did get into the mills before it was cleaned, and produced, of course, a very unpleasant kind of flour.

Similarly, one of the complaints against rye imported from the United States is that it too frequently contains oats in considerable

quantities, making it necessary to reclean the rye before it can be milled and made into flour. As the rye is imported for bread purposes, it is important to have it free from oats and other grain.

Our barley has also been complained about in some cases because of its dirty condition. An instance came to our notice where it was claimed that as much as 10 per cent of impurities occurred in a cargo.

According to the testimony of the foreign importers, the complaints made against American barley are mostly of recent origin. Some years ago American barley was held in high favor abroad. It obtained a market in Europe that was formerly controlled by Russia. But the importers say that within the last few years complaints against the condition of our barley have been numerous, greatly endangering our market, and the probability is that unless some measures are taken to secure more care in cleaning export barley much trade will be lost to us.

NEED OF GREATER CARE IN CLEANING GRAIN.

Regarding our grain export trade as a whole, I think I am safe in saying that the greatest obstacle to the maintenance and extension of that trade lies in the fact that our exporters do not always exercise proper care in cleaning the grain before shipment. In view of the increasing competition we are beginning to meet with from other grain-exporting countries, it is highly important that this ground for complaint should be speedily remedied.

MISUNDERSTANDING OF TERM "OFFICIAL."

Before dropping the subject of grain exports, I want to recur again to the matter of the certificates, and to repeat that it seems to me unfortunate that the certificates issued by our boards of trade should be sent out under the title of "official" inspection. [Producing certificate.] The term "official" in this case is undoubtedly misleading, and it is a question whether it would not be a wise thing to prevent further misunderstanding on that ground by prohibiting boards of trade and chambers of commerce from using the appellation "official" on their certificates. It is unquestionably a cause of much misunderstanding abroad.

Q. Do you think it conveys the idea to the foreign importer that it is a Government official inspection?—A. The foreign importer very generally believes that these certificates are issued by the United States Government. I have talked with many importers abroad who were under that impression, and who were surprised to learn that the United States Government was in nowise responsible for the certification of our export grain.

Q. (By Mr. FARQUHAR.) Does not nearly every single purchaser or Liverpool broker have his own agent in the United States here in our markets?—A. Many of the larger importers have their agents here.

Q. Those that are of any account at all?—A. Many of the large importers have their representatives here, but these certificates, of course, pass into the hands of other buyers. The importers, in reselling their imported grain, sometimes base their contracts on the original certificate, and in such cases the secondary buyers have not the same means of ascertaining the real status of the certificate.

Q. The Government inspection would cover all doubts and would verify to the consignee or the factor or the commission merchant or the original purchaser or anyone that there was bona fide inspection here when put on board of vessels, subject, of course, to stand the transportation and delivery?—A. Yes.

IMPORTANCE OF CARE IN LOADING CORN.

Q. (By Mr. A. L. HARRIS.) Do you desire to go any further into grain?—A. One thing occurs to me that I intended to add in connection with the loading of grain. I said that it was a question whether corn ought ever to be loaded in the bunkers, since they were so close to the boilers and therefore so liable to become heated on the voyage. The same objection applies, of course, to the loading of grain in any of the holds that are adjacent to the boiler or engine space. In the distribution of the cargo the corn ought, when possible, to be loaded in holds that are remote from amidships.

Q. Would this trouble be obviated to some extent if the bottoms were controlled by Americans? You spoke a moment ago about the excellent facilities on land.—A. I have no doubt that it would be far easier to control the methods of transportation if we owned the ships. Does that answer your question?

Q. Yes; that is what I wanted.—A. Carelessness sometimes occurs as regards the stowing of grain with other merchandise in the same hold. A case recently came to my attention where a hold was partially filled with corn, and then upon that corn were stowed bales of cotton. Such a condition of affairs, of course, ought not to be permitted. It goes without saying that corn put down in the hold and then covered over completely with bales of cotton is going to sweat and become damaged. I speak of this case to suggest that there is a great deal to be considered in regulating the methods of shipping grain across the ocean.

PACKING OF COTTON FOR EXPORT.

Q. What have you to say in regard to the export of cotton?—A. The principal ground of criticism against American cotton in foreign markets is the poor packing. A great deal of our cotton is still baled in the old way. We ship it in large bales, weighing about 500 pounds, and much of it is put up in inferior baling materials. The damage that thus results is not so apparent in the United States as it is at the

end of the journey across the sea. Our exporters do not seem to realize the conditions that our cotton has to meet in foreign countries. The packing is generally sufficiently strong to carry the cotton safely to the seaboard and to get it aboard ship, but when it comes to be unloaded in the foreign port great loss is apt to result. Under the rough handling to which the bales are subjected in the process of unloading from the ship's holds to the docks, the flimsy baling material becomes badly torn, and usually a large amount of cotton is shredded off and strewn along the docks. Such cotton is practically ruined, becoming waste cotton. The coverings of the bales are generally so badly damaged that before the cotton can be reshipped much patching has to be done, and often entire rebaling. Foreign importers naturally complain of this, because it subjects them to so much additional expense.

An interesting instance came to my attention while in Russia last summer where the insecure packing of American cotton resulted in a great deal of loss by theft. We send considerable quantities of cotton to Russia. Most of it is transshipped for the Baltic at such ports as Liverpool, Bremen, and Copenhagen, although within the last year or two some important consignments have gone direct to Russia without transshipment. The United Steamship Company, of Copenhagen, has been particularly enterprising in its efforts to establish a direct service between the United States and Baltic Russia, and the boats of that company have recently been carrying cotton right through from New York to St. Petersburg. However, the chief part of the American cotton marketed in Russia still goes in the first instance to other European ports, where it has to be transshipped in order to be forwarded up the Baltic. By the time that cotton has been discharged at the Russian ports of Reval and St. Petersburg it is apt to be in very poor condition as regards the baling. From these Baltic ports it has to be sent overland by rail to Moscow, where the Russian manufacture of cotton goods is chiefly carried on. Owing to the numerous rents and tears that occur in the bale coverings because of the poor baling materials, a great deal of cotton is lost before it reaches Moscow. It generally goes there by slow freight, frequently with many stops, and I was informed that the peasants along the route sometimes steal great quantities of this cotton from the trains at night, pulling it from the damaged bales in large shreds, as they can readily do, owing to the insecure packing. In this manner the importers at Moscow have been losing so much of their consignments from America that they are now striving, as far as they can, to replace our cotton with that produced in southern Russia. In the south of Russia they are beginning to grow American cotton quite extensively. Some years ago they secured American seed, and already they have had considerable success in the production of our upland cotton. They take great pains to bale it securely. They use a much smaller bale

than the American, and pack it so tightly and firmly that no cotton can be lost or stolen from the bale. By such methods they are gradually establishing quite a trade at Moscow, to our loss.

I spoke of this case as a rather interesting one, illustrating how a trade can be injured by neglect in providing proper packing materials. Some of our cotton growers, in order to save a few cents on a bale, make it a practice to use the cheapest possible baling materials that will carry their product to the port. While such a short-sighted practice may result in a slight saving at the outset, it is certain in the long run to do great damage to our trade. Other cases similar to that in Russia as regards the poor baling of American cotton have come to my attention abroad, and I think I may say that, generally speaking, our cotton export trade is in this respect fairly open to criticism. It is to be hoped that the more general adoption of the round or cylindrical bale will remedy this obstacle to our export trade in cotton.

I have mentioned the case of cotton especially because this product is decidedly our most important agricultural export, but it does not by any means afford the only instance of this kind. There are many other cases in our export trade where failure to give proper attention to the packing of the product is working to the detriment of the trade.

Q. Then the American producer and the American shipper, you think, suffer to some extent, owing to the imperfect manner in which the goods are sometimes sent from this country?—A. Yes.

Q. And greater care should be taken along these lines?—A. Yes; it is very important.

QUESTION OF GOVERNMENT AID IN EXTENDING FOREIGN MARKETS.

Q. It is a very general complaint among agricultural producers that little effort is made to secure a foreign market for their products. What do you know about that?—A. I think I may fairly say that, comparatively speaking, little effort has been made in the interests of the United States farmer as regards the exportation of his produce. The manufacturer seems able to accomplish more in this direction; he seems to have facilities for pushing his trade that the farmer has not had, or at least has not taken advantage of. I think it is true that more active measures have been taken to make a market abroad for American manufactures than for the produce of American farms.

Q. (By Mr. KENNEDY.) Is not that very largely because the American manufacturers push for these markets themselves?—A. Exactly. The manufacturer seems to be in closer touch with the foreign market than the farmer. He sends his representatives abroad, establishes his agencies there, and, speaking generally, there seem to be more facilities for the extension of trade in manufactures than there are for upbuilding the agricultural export trade.

Q. Manufacturers do for themselves the work which, if done for

he farmers, must perhaps be done by the Government or some other gency?—A. There is a good deal in that.

Q. (By Mr. A. L. HARRIS.) Is it possible for the farmer, owing to is interests being in the hands of so many, to take up the subject of ncreasing his exports, like it is for the manufacturers, where large apital is invested under one control and they can send out their agents o look after foreign markets?—A. It is certainly not so easy, and I hink the question that you have put discloses the secret of the difference.

NEED OF MORE LIBERAL APPROPRIATIONS FOR DEPARTMENT OF AGRICULTURE.

Q. Have you any suggestions to make along the line of the extension of foreign markets for farm products?—A. I believe, first of all, that in the interest of the farmer the Agricultural Department ought to be provided with more liberal means to develop, as far as may be, by governmental assistance, the agricultural export trade. I do not think that enough attention has hitherto been given by the Government to that side of the farmers' interests. We have not done nearly so much as other agricultural countries have done. I spoke of the measures taken by the Canadian government. The appropriation that enabled the department of agriculture for the Dominion to inaugurate the measures I described amounted to $100,000, which was certainly quite a liberal appropriation. The fund that was placed at the disposal of our own Agricultural Department to make experimental shipments of dairy and other agricultural produce was only $25,000. The Australian colonies, like Canada, have also been liberal in appropriating funds to assist the farmer in finding a profitable foreign market for his produce. I feel that much more could be done for the farmers of the United States than has thus far been possible with the scanty means placed at the disposal of our Department for such work.

USEFULNESS OF SPECIAL AGENTS ABROAD.

I believe in the plan of sending abroad special agents, at Government expense, to study foreign markets. I think we should have a goodly number of agents abroad, working solely in the interest of our farm products. These agricultural countries I have mentioned all maintain such agents, not only for the purpose of studying foreign markets and the opportunities they afford for increased trade, but also for the purpose of studying the export methods of other countries. Canada sent her agents to Denmark—the Australasian colonies did the same—to gather information there as to the best methods of shipping dairy and other farm produce. Now that Canada is beginning to compete somewhat with Denmark, especially now that Canada is beginning to cut into the Danish bacon market in England, the Danes are sending agents to Canada to see if there is anything in the Cana-

dian methods of production and exportation that would be an improvement over their own.

SPECIAL AGENTS AS COMPARED WITH CONSULAR SERVICE.

Q. (By Mr. FARQUHAR.) Can not the diplomatic and consular service do the whole thing properly?—A. With certain modifications of the diplomatic and consular service I think undoubtedly most of the objects could be attained, but I do not think it possible as the service is now constituted. I do not believe the consular officers can render the same kind of service that could be had from traveling agents.

Q. You mean the paid agents of the Department?—A. Paid agents of the Department, sent from the Department, if possible. We have tried the consular service, and it has not been altogether satisfactory for this purpose. In the first place, a consul is obliged to remain practically all the time at his place of business—at Hamburg, or Bremen, or some other city, as the case may be—and while he can watch in a general way the trade at a single port, he has to remain right there in order to attend to the routine duties of the consular office. Unfortunately, the course of trade can not be satisfactorily investigated by a man confined to a single place. In order to get a fair idea, for instance, of the butter export trade of Denmark, it would be necessary to travel over that country, to go from the creamery to the terminal warehouse at the port, and, in fact, it would be advisable to leave the port and accompany the butter on the steamer to its place of destination. This is the plan followed by these other agricultural countries that are sending out agents. The agents are instructed to begin at the beginning and to trace the trade to its final destination, in order to gain an accurate knowledge of all its conditions. The consular officers are necessarily engrossed a good deal of the time with the routine of the consular business. As a matter of fact, they can not always take the time necessary to make a thorough investigation of special inquiries sent to them. Furthermore, a consul is appointed to represent the United States trade interests as a whole, and when the Department of Agriculture, through the State Department, as is necessary, sends to him for certain information about a particular feature of the agricultural export trade, that consul may have on file in his office, and probably has, a number of requests from other sources that take precedence, and so the Department of Agriculture has to wait. The consul's attention is necessarily divided. He is not working in the interest of agriculture any more than he is in the interest of other industries, and that, of course, is a great objection from our point of view. It is very important for us to have men abroad whom we can direct and who can work under the Department's supervision. That is the reason why I feel that we never can expect from the consular service, no matter how much it may be improved, such results as other countries are getting from

the employment of agricultural experts working in foreign countries. I believe that the employment of special agents of the Department abroad is the most feasible way of getting the information we want. By placing the right kind of men in competing countries and in countries that afford us most of our markets, we can undoubtedly gather information that will be of great value in extending our trade.

AGRICULTURAL ATTACHÉS AT EMBASSIES.

To supplement the work that can be expected from these special agents, I am in favor of appointing agricultural attachés to our embassies in certain of the most important countries. I am in favor of that plan because of our experience in one case, that of Dr. Stiles, who was stationed at Berlin as an agricultural attaché. Although nominally a diplomatic official, and having from the State Department an appointment as such, he was paid by the Department of Agriculture and was under the direction of our Department. His work was of great advantage to the Department. He traveled about over Europe, as occasion seemed to demand, following the instructions of the Department, in order to investigate matters affecting our agricultural export trade, and in this capacity he rendered, on the whole, a most valuable service. His appointment was, of course, something of an experiment, but I think that it was eminently successful. It is my belief that a few such agricultural attachés, having a diplomatic status, could be of great service abroad to our agricultural interests. Their diplomatic status would give them certain advantages over other agents.

Q. (By Mr. A. L. HARRIS.) They would be very valuable in studying the wants and tastes of foreign people also, so as to learn the proper preparation of our agricultural products for export, would they not?—A. That is, of course, at the base of our export trade. First of all, we must put up a product that will be acceptable in the market to which it is sent. It is of the highest importance to study the peculiar tastes and requirements of the various foreign markets in order that we may know what kind of a product to prepare for export.

ADDITIONAL EXAMPLES OF EXPORT MEASURES TAKEN BY FOREIGN COUNTRIES.

EXPORTS OF BACON FROM DENMARK.

I spoke of the Canadian bacon trade competing somewhat with the Danish bacon trade. The Danes have been preeminently successful in meeting the requirements of foreign markets, and especially of their great foreign market, the British market. Soon after the Danes had placed their export trade in butter on a sure footing they began to reach out after a market for bacon in Great Britain. They studied the wants of that market and they produced a bacon that met those

wants. In 1880 they exported about 13,000,000 pounds of pork, chiefly bacon. In 1890 they exported 65,000,000 pounds. In 1899, the last year for which we have their figures, they exported 135,000,000 pounds, sending most of it to Great Britain. In less than twenty years they developed a trade that now amounts in value to about $15,000,000. They did so, as I said, by studying the requirements of the British market and meeting those requirements.

EXPORTS OF BACON FROM CANADA.

Q. Are there any other countries becoming competitors of American products along the line of studying the wants and tastes and methods of supplying those wants or tastes?—A. As the Canadian people followed the Danes in their methods of exporting butter, so they have followed them in regard to the bacon export trade—the two products naturally go hand in hand. Canada took the same measures that Denmark had taken to get at the requirements of Great Britain in that product, and the result is shown by the Canadian export figures. In 1890 Canada shipped of bacon about 7,000,000 pounds, chiefly to Great Britain. In 1899, within a decade, the Canadian exports amounted to nearly 112,000,000 pounds.

EXPORTS OF BACON FROM THE UNITED STATES.

Our own exports of bacon, of course, are enormous, but they do not show any such growth as I have just exhibited for Denmark and Canada. In fact, there seems to be danger of a decline in our export trade in bacon. We are beginning to feel seriously the competition of these other exporting countries. The first year for which our shipments of bacon were separately reported is 1881. In that year we exported 673,000,000 pounds of bacon, valued at about $54,000,000. In 1890 we exported 532,000,000 pounds, valued at about $39,000,000. In 1895 we exported only 453,000,000 pounds, valued at about $38,000,000. Last year, 1899, we exported 563,000,000 pounds, worth about $42,000,000. While our exports for 1899 were larger than those for 1890 and 1895, you will see that they were considerably smaller than our exports in 1881, which was about the time when the bacon shipments from these other countries were beginning to become prominent. Taking the record of 1899, we find that we sent abroad in that year over 100,000,000 pounds less than in 1881, about twenty years ago. It is a question whether in the years to come we shall not feel still more seriously the competition of such countries as Denmark and Canada, and also the Australasian colonies that are now beginning to ship bacon to England, unless we take some measures to adapt our product more closely to the requirements of the British market.

KIND OF BACON PREFERRED IN ENGLAND.

The bacon preferred by the British nation is what is known as the Wiltshire bacon. It is different from our bacon in being much leaner and firmer. The objection to our bacon is that it is too fat, being a corn-fed bacon. It does not bring as high a price.

Q. They prefer a streak of lean and a streak of fat, instead of all fat?—A. They like a leaner bacon than ours. The Tamworth and Yorkshire swine seem to be the preferred breeds for producing bacon for the British market.

Q. (By Mr. FARQUHAR.) Is not one of the reasons that we fatten our hogs too fast, and that makes a fatter meat?—A. Yes, they are too fat; that is the chief objection.

PRICES OF BACON IN ENGLAND.

I was about to quote the import prices in England of the bacon received from the United States, from Canada, and from Denmark. In 1899 the average annual price of the bacon imported into the United Kingdom from the United States was about 7 cents a pound, the exact quotation being 6.96 cents. The average price of the bacon imported from Canada was 7.3 cents a pound. The average price of the bacon imported from Denmark was 10.6 cents per pound. In other words, there was a difference during 1899 of about 3½ cents per pound in favor of the Danish pork over ours, which is very significant. When you consider the fact that we exported last year 563,000,000 pounds of bacon, most of which went to Great Britain, you can readily see that even a slight enhancement in the price would have meant an enormous gain to the American farmer. If the importance of this matter could be brought home to producers in the United States, so as to lead them to change their methods of production by selecting only the preferred bacon breeds and feeding the kind of rations that will produce the bacon most highly favored abroad, it would be a most profitable lesson, I am sure, for the farming community.

The case of bacon illustrates in a very striking manner, I think, the point that you just suggested about the importance of ascertaining and meeting the exact requirements of foreign markets.

METHODS ADOPTED BY AUSTRALASIAN COLONIES.

Q. (By Mr. A. L. HARRIS.) I believe you have covered all the points that I have down here, Professor, together with suggestions as to the possibilities of the extension of our markets, and I do not know but so far as additional legislation is concerned. If you have anything further, however, to suggest in regard to any remedy for the grievances that you have mentioned, the commission will be glad to hear you.—A. I spoke quite fully of what Canada had been doing, and referred

ures as regards our own exports if we do not wish to fall behind. The figures that I have quoted as to the exports of butter from Denmark, Australasia, and Canada, the exports of cheese from Canada, and of bacon from Denmark and Canada, are, to my mind, very significant, and should serve as a warning to our own producers who depend upon the foreign market.

TIME FOR MORE ACTIVE GOVERNMENT ATTENTION.

Q. (By Mr. A. L. HARRIS.) You think the time is coming, if not here, that the Government may well take some steps in the way of extending and holding our markets?—A. I do, most assuredly. I think it is time for the Government to give the subject more active attention.

VALUE OF CONSULAR AND DIPLOMATIC AID.

Q. Have you anything additional that you care to suggest?—A. There is one thing further that I should like to say to the committee before closing. I do not wish to be misunderstood about my reference to the consular service. I do not want to underestimate the value of the services that the consular corps can render and does render. There is no question that the consular service as at present constituted is supplying a great deal of valuable information to our exporters. I think that the services of the consuls are, as a rule, decidedly valuable, but I have been impressed with the importance of adopting some additional measures, such as are taken by the countries with which we have to compete. I am in favor of sending out as foreign agents men specially qualified to acquire information regarding the agricultural export trade. I believe that experts along that line can add greatly to the service we are receiving at the hands of the consular officials. There are also some special advantages to be gained by having a few representatives in the diplomatic service—representatives solely of the agricultural interests. There are several cases, as you know, where agricultural attachés have been appointed by other nations. One case is that of Baron Herman, here in Washington, who was appointed by the German Government as an agricultural attaché to its embassy in the United States. His expert knowledge of agricultural matters makes him remarkably well qualified for the position, and he is undoubtedly rendering most valuable services to the German Government. Only a few days ago Baron Herman called at my office to present a similar attaché who had just been appointed by the Austro-Hungarian Government as an agricultural expert at Washington. Foreign agriculturists recognize the advantage of having, in addition to the consular service, special representatives abroad working solely for the agricultural interests, and I feel that it is important for us to adopt the same advantageous measures. We should avail ourselves of equal facilities or better.

VALUE OF AMERICAN AGRICULTURAL EXHIBITS ABROAD.

There is another thought that has just occurred to me. It is that a great deal can be done for our export trade through the medium of the various expositions that are held periodically all over the world. I believe that it would be profitable for the Government to take even greater measures than it has in the past to have at all such expositions an ample display of our agricultural products.

CONCLUSION.

In answering the interrogatories of the committee, I have not pretended to mention all the measures that might be thought of to extend our agricultural export trade. I have simply endeavored to touch upon what appeared to be the most important features of the subject as suggested by your questions.

(Testimony closed.)

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in a general way to what the Australasian colonies had attempted as regards governmental control of and aid to the agricultural export trade. I should like to mention a plan that has been adopted by New South Wales, one of the most progressive of the Australasian colonies, in the interest of the export trade. In 1895 the government of that colony appointed an export board, so called—"Board for Exports" was the official title, I believe—to take under consideration plans for the development of a larger export trade in the products of the colony. The method pursued by the board was, at the outset, to hold conferences with leading representatives of the various agricultural interests, such as the dairying industry, the meat exporters, the grain shippers, etc. The leading producers and shippers of the various export commodities were called into consultation by the board and their opinions solicited as to the best measures to be taken to assist their particular branches of the trade. As a result of these conferences a great deal of valuable and practical information was elicited, and the board, on the strength of what it had thus learned, made certain recommendations to the government, which were afterwards carried out.

Government aid and control.—In a general way the measures adopted in Australasia correspond rather closely to what has been done in Denmark and in Canada; but, if anything, the Australasian colonies have gone even farther than those countries in the direction of government aid and control. New South Wales and Victoria, I think, were the prime movers in the project to assist the export trade of Australasia by State intervention, but the other colonies have been quick to see the advantages of such a movement, and they are now adopting similar provisions.

Better transportation and terminal facilities.—One of the first things done by the Australasian colonies to facilitate their export trade was the securing of better transportation facilities by rail from the farming districts to the ports of shipment. Cold storage on the trains was procured, as it had been in Canada, and cold-storage warehouses were established at the ports of shipment where products could be safely kept until the time of sailing. Arrangements were also made with the steamship companies to provide regular sailings from the ports to the British market and to furnish refrigeration facilities on board. Another method taken by the Australasian colonies was the establishment of cold-storage depots and warehouses at London and other British ports. Several of the colonies have depots there for their products, under the management and control of government agents, who receive the produce as it comes from the ship, keep it in cold storage when necessary, and take measures for its proper disposal in the market. The establishment of these terminal depots has undoubtedly rendered great assistance to the Australasian export trade.

Special agents abroad to study methods.—The colonies of Australasia

have also adopted the policy of sending agents to study the methods of other exporting countries. Their agents have come to the United States to study our methods; they have gone to Canada to study the methods there; they have visited Denmark and other countries for the same purpose—and in each instance have reported to their own governments the results of their investigations. These colonial governments have taken pains to study the methods of other countries in order to follow them, as far as it seemed wise, in developing their own trade.

Prizes for best results.—The Australasian colonies have also adopted one of the most important plans inaugurated by Denmark, namely, that of offering prizes for products put up in the best shape for export. The government furnishes the producers with careful instructions as to the kind of product, style of packing, marking, labeling, etc., desired for the export trade, and under these conditions, at stated intervals, contests are held, at which liberal prizes are offered for the products that best fill the requirements. This plan of offering prizes for superior export produce, and thus furnishing an immediate incentive to the producer, was a very important factor, it is said, in bringing the export butter, bacon, etc., of Denmark up to a high standard, and the official reports from the Australasian colonies indicate that it has also been an important factor there.

ADULTERATION OF EXPORT PRODUCE.

Q. (By Mr. KENNEDY.) Do you believe that the adulteration of manufactured products in America is ruining the foreign markets for those products, and that these people that you speak about seeing abroad are thus taking advantage of it to gain those markets with pure-food products?—A. Wherever we are losing trade on the ground you mention, these other exporting countries are unquestionably taking advantage of the fact. When the inferior quality of one of our products causes it to find a less ready sale in a foreign market, our competitors are quick to grasp the opening thus afforded; there is no doubt of that.

RECENT GROWTH OF COMPETITION.

And, generally speaking, I wish to say that the question of competition in regard to our agricultural exports has only of late been assuming such great importance. It has become a more vital question within the last few years because of these very measures that are being taken by competing countries to gain and control the foreign markets upon which we have hitherto depended. The measures that I have mentioned are all comparatively recent. Foreign countries have been doing more within the last decade than ever before in the way of pushing by governmental assistance the exports of their agricultural products. It is therefore important for us to take more active meas-

ures as regards our own exports if we do not wish to fall behind. The figures that I have quoted as to the exports of butter from Denmark, Australasia, and Canada, the exports of cheese from Canada, and of bacon from Denmark and Canada, are, to my mind, very significant, and should serve as a warning to our own producers who depend upon the foreign market.

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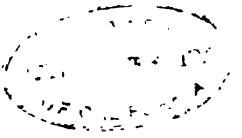
Tobacco—12.

U. S. DEPARTMENT OF AGRICULTURE.

Report No. 68.



CATALASE,

A NEW ENZYM OF GENERAL OCCURRENCE,

WITH SPECIAL REFERENCE TO THE TOBACCO PLANT.

BY

OSCAR LOEW,

Division of Vegetable Physiology and Pathology,
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WASHINGTON:
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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
DIVISION OF SOILS,
Washington, D. C., September 28, 1900.

SIR: I have the honor to transmit herewith a manuscript on a new enzym occurring in the tobacco plant, and probably having much to do with the fermentation and, possibly, with the development of flavor and aroma in tobacco. It represents work done in cooperation with the Division of Vegetable Physiology and Pathology of this Department.

Respectfully,

MILTON WHITNEY,
Chief of Division.

Hon. JAMES WILSON,
Secretary of Agriculture.

LETTER OF SUBMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
DIVISION OF VEGETABLE PHYSIOLOGY AND PATHOLOGY,
Washington, D. C., September 28, 1900.

DEAR SIR: In continuation of the cooperative work of this Division and the Division of Soils, I hand you herewith a paper prepared by Dr. Oscar Loew, on catalase, a new enzym of general occurrence, with special reference to the tobacco plant. The paper is the result of investigations carried on in connection with the tobacco work in your charge.

I regret very much to state that this will be the last of the series of important papers by Dr. Loew which will be brought out in cooperation with your Division, as he has just accepted a position in the Imperial University at Tokyo, Japan.

Respectfully,

B. T. GALLOWAY,
Chief of Division.

Prof. MILTON WHITNEY,
Chief Division of Soils,
In charge of Tobacco Investigations.

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Q. (By Mr. A. L. HARRIS.) You think the time is coming, if not here, that the Government may well take some steps in the way of extending and holding our markets?—A. I do, most assuredly. I think it is time for the Government to give the subject more active attention.

VALUE OF CONSULAR AND DIPLOMATIC AID.

Q. Have you anything additional that you care to suggest?—A. There is one thing further that I should like to say to the committee before closing. I do not wish to be misunderstood about my reference to the consular service. I do not want to underestimate the value of the services that the consular corps can render and does render. There is no question that the consular service as at present constituted is supplying a great deal of valuable information to our exporters. I think that the services of the consuls are, as a rule, decidedly valuable, but I have been impressed with the importance of adopting some additional measures, such as are taken by the countries with which we have to compete. I am in favor of sending out as foreign agents men specially qualified to acquire information regarding the agricultural export trade. I believe that experts along that line can add greatly to the service we are receiving at the hands of the consular officials. There are also some special advantages to be gained by having a few representatives in the diplomatic service—representatives solely of the agricultural interests. There are several cases, as you know, where agricultural attachés have been appointed by other nations. One case is that of Baron Herman, here in Washington, who was appointed by the German Government as an agricultural attaché to its embassy in the United States. His expert knowledge of agricultural matters makes him remarkably well qualified for the position, and he is undoubtedly rendering most valuable services to the German Government. Only a few days ago Baron Herman called at my office to present a similar attaché who had just been appointed by the Austro-Hungarian Government as an agricultural expert at Washington. Foreign agriculturists recognize the advantage of having, in addition to the consular service, special representatives abroad working solely for the agricultural interests, and I feel that it is important for us to adopt the same advantageous measures. We should avail ourselves of equal facilities or better.

VALUE OF AMERICAN AGRICULTURAL EXHIBITS ABROAD.

There is another thought that has just occurred to me. It is that a great deal can be done for our export trade through the medium of the various expositions that are held periodically all over the world. I believe that it would be profitable for the Government to take even greater measures than it has in the past to have at all such expositions an ample display of our agricultural products.

CONCLUSION.

In answering the interrogatories of the committee, I have not pretended to mention all the measures that might be thought of to extend our agricultural export trade. I have simply endeavored to touch upon what appeared to be the most important features of the subject as suggested by your questions.

(Testimony closed.)

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Tobacco—12.

U. S. DEPARTMENT OF AGRICULTURE.

Report No. 68.

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CATALASE,

A NEW ENZYM OF GENERAL OCCURRENCE,

WITH SPECIAL REFERENCE TO THE TOBACCO PLANT.

BY

OSCAR LOEW,

Division of Vegetable Physiology and Pathology,
Detailed to the Division of Soils.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1901.

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
DIVISION OF SOILS,
Washington, D. C., September 28, 1900.

SIR: I have the honor to transmit herewith a manuscript on a new enzym occurring in the tobacco plant, and probably having much to do with the fermentation and, possibly, with the development of flavor and aroma in tobacco. It represents work done in cooperation with the Division of Vegetable Physiology and Pathology of this Department.

Respectfully,

MILTON WHITNEY,
Chief of Division.

Hon. JAMES WILSON,
Secretary of Agriculture.

obtained from culture fluids of *Penicillium glaucum* in the manner above described. The crude β-catalase from animal organs contains more proteins as impurities than that from sweated tobacco.

While β-catalase[1] behaves like an albumose, α-catalase behaves like a nucleo-proteid, since it is not soluble in water alone. It can be brought into solution by dilute alkaline liquids and precipitated again therefrom unchanged on the addition of acetic acid.[2] Sweated tobacco was finely pulverized and repeatedly extracted with a large amount of cold water, to which a few drops of ether had been added in order to prevent bacterial growth, and then treated for fifteen hours with a 0.2 per cent solution of caustic soda. This alkaline extract, after filtering, was cautiously acidulated with acetic acid (mere neutralization does not yield a precipitate), and the precipitate filtered off after standing one hour. This precipitate possessed, in a considerable degree, the power of decomposing hydrogen peroxid, while the liquid filtered from it did not show this power in the least. This behavior was also observed with green tobacco leaves. Six hundred square centimeters of healthy tobacco leaves from the greenhouse were crushed to a fine pulp with sand and left for three hours in contact with a 0.2 per cent solution of ammonium carbonate. The opalescent filtrate obtained had in a high degree the power of catalyzing hydrogen peroxid. Upon adding dilute acetic acid until a slight acid reaction was reached, a fine flocculent precipitate containing the active principle was formed, the filtrate from this precipitate being devoid of the catalyzing property.

The α-catalase is, however, not very readily extracted by alkaline liquids. Even a 1 per cent solution of sodium carbonate dissolves it but slowly. The solution thus obtained from sweated tobacco that had been well exhausted with water before the treatment with sodium carbonate was begun does not give the characteristic blue reaction for oxidase and peroxidase (a previous slight acidulating of the alkaline liquid is necessary for these tests), hence α-catalase also has a close relation to these two oxidases. In these tests 10 per cent alcohol was added to the extracting liquids to prevent bacterial growth during the time of extraction.

Connecticut tobacco, cured in 1899, was repeatedly extracted with water saturated with chloroform. After the removal of the soluble compounds this tobacco was left for two days with a 0.5 per cent solution of sodium carbonate, just enough to cover the soaked tobacco with the solution. Then the liquid was separated from the tobacco and 20 cc. of the brown-colored filtrate mixed with 5 cc. hydrogen peroxide, and in fifteen minutes 7.5 cc. of oxygen were obtained.

[1] Special tests have shown that it is not a coagulable albumin.

[2] This militates against the supposition that α-catalase might be merely β-catalase in a state of absorption, the same way that colored matters are absorbed by charcoal.

uantity of the expressed residue corresponding to nearly 2 grams f dry matter, after being washed well and again expressed, was sus- ended in 20 cc. water and 10 cc. hydrogen peroxid added; in fifteen inutes 31 cc. of oxygen were obtained. This shows that a solution f 0.5 per cent sodium carbonate did not extract all the α-catalase even n two days.

It is more difficult to prepare the α-catalase free from peroxidase hen using green tobacco leaves than when cured and fermented eaves are used, since it takes a long time to wash out the peroxidase rom the pulp prepared from the fresh leaves. For example, 30 cc. f turbid, not filtered, juice prepared from tobacco leaves was mixed ith ten times this quantity of water and filtered after standing fifteen ours, leaving a green residue in the filter, which even after pro- onged washing yielded the reaction for peroxidase, while that for xidase had ceased to be produced in the wash waters after a short ime.

Water alone dissolves only traces of α-catalase at 20° C., while rolonged action of water at a moderate elevation of temperature radually splits off β-catalase, the process being favored by adding a mall proportion of sodium carbonate.

The following test shows that even very large quantities of water lone do not extract α-catalase to any noticeable extent. Two grams f finely pulverized cured tobacco were extracted for four hours with 0 cc. of water at 20° C. and the residue washed until the filtrate was early colorless. This extracted tobacco yielded in fifteen minutes, pon the addition of 5 cc. hydrogen peroxid and 20 cc. water, 42 cc. oxygen. Two grams of the same tobacco were now extracted with 1 liter of chloroform water for eighteen hours. The powder yielded, fter washing under the same conditions as before, 40 cc. oxygen.

It seems strange that neither Schœnbein nor Jacobson observed that the property of catalyzing hydrogen peroxid may be due to a soluble as well as to an insoluble substance. Schœnbein mentions only once— without, however, altering his opinion that the enzyms were the cause of that catalysis—that the filtered extracts of certain vegetable mat- ter show much less power of catalyzing hydrogen peroxid than the unfiltered. Jacobson also used, in his experiments mentioned above, the crude turbid extracts, but not purified enzym preparations. He used, for instance, an emulsion prepared from crushed almonds instead of purified emulsin.

The following tests leave no doubt that the transformation from the insoluble to the soluble catalase really can take place. Sweated tobacco rich in α-catalase was finely pulverized, repeatedly extracted with chloroform water[1] at the ordinary temperature, and, when β-catalase

[1] Care must be taken in the application of chloroform water as an antiseptic that a full saturation is preserved, otherwise certain microbes will gradually develop.

could no longer be extracted, heated with a 1 per cent solution of sodium carbonate for one hour at 40° C. The mixture was passed through flannel and the filtrate moderately acidulated with acetic acid to precipitate nucleo-proteids. The clear filtrate now obtained had a considerable power of catalyzing hydrogen peroxid, although it could not contain α-catalase any longer.

In a second trial the exhausted tobacco was heated for two hours at from 45° to 50° C., with a solution of 0.2 per cent sodium carbonate, the filtrate acidulated with acetic acid, again filtered, and the filtrate now saturated with ammonium sulphate at the ordinary temperature. By this treatment the active principle was salted out, as is the case with β-catalase, the precipitate showing powerful action while the filtrate showed only slight traces of activity. It may also be stated that the salted-out product was easily soluble again in water and can not therefore have consisted of nucleo-proteids.

Since there is a zymogen for every well-known enzym, the supposition seems justifiable that there is also a zymogen of catalase. Various observers have shown that animal or vegetable cells, before they form the enzyms, are rich in small granules, which disappear in a measure as the enzyms are formed. The substance first secreted by the nucleus, forming the granules in the cytoplasm, is distinguished by Macallum as pro-zymogen. Vines, in his investigation on the presence of diastase in leaves, observed that the turbid unfiltered extracts saccharified more starch than the clear filtered ones. Brown and Morris found, furthermore, that powdered leaves are more powerful in diastasic action than an aqueous extract prepared from the same amount of leaf. Whether the action here is caused by a zymogen which is gradually transformed into diastase, or whether the diastase itself is retained to a certain extent by the solid compounds of the leaf, has not been decided. It has been observed that highly dilute acids bring on the transformation of zymogen into enzym. J. Reynolds Green has found that certain rays of light—located chiefly in the red, orange, and blue regions of the spectrum—and a prolonged exposure to a temperature of 38° C. can also cause this change.[1]

The existence of a zymogen of catalase in tobacco leaves appears probable from an observation of the writer that in the process of sweating tobacco in bulk at a temperature of from 40° to 50° C. the power of catalyzing hydrogen peroxid is increased, not only for the soluble but also for the insoluble catalase. Digestion with 0.1 per cent oxalic acid at from 25° to 36° C. proved a failure in this direction, since the catalytic power was decreased thereby. Acids therefore seem unsuited to transform zymogen into enzym in the case of catalase.

[1] Philosoph. Transactions, vol. 188 (1897). On the other hand, diastase itself is gradually destroyed by white light, as the same author has observed.

EFFECTIVENESS OF THE β-CATALASE.

For the following tests a preparation of crude β-catalase was used which was obtained by salting out with ammonium sulphate a concentrated cold-prepared extract of tobacco recently sweated in bulk. The precipitate, after being pressed between filter paper, was permitted to dry at the room temperature. A 1 per cent solution of this crude β-catalase, still containing a considerable amount of ammonium sulphate, was prepared. One cc. of this solution was mixed with 20 cc. of water and 2 cc. of common hydrogen peroxid (neutralized). The volume of oxygen evolved for different lengths of time was as follows:

	cc.
After 5 minutes	12
After 10 minutes	17
After 16 minutes	20.2

This result shows that in the dilution of 1:2,000 the crude enzym decomposed six times its own weight of anhydrous hydrogen peroxid in sixteen minutes.

In the next test the reaction of the mixture was kept slightly alkaline and the amount of hydrogen peroxid increased to 10 cc., the other conditions being the same as before:

	cc.
After 5 minutes	20
After 10 minutes	38
After 15 minutes	55
After 40 minutes	76
After 55 minutes	80
After 15 hours	101.5

In a further test 1 cc. of the 1 per cent catalase solution mentioned above was diluted with 200 cc. water and 1 cc. hydrogen peroxid added. One minute after the mixture was made the reaction for hydrogen peroxid was still very powerful.[1] After twenty-five minutes, however, the reaction was very weak, and after thirty-two minutes there was no trace of hydrogen peroxid left. This test was repeated with the modification that the amount of water was increased to 500 cc. and the amount of hydrogen peroxid decreased to 0.5 cc. After twenty-one minutes the reaction for hydrogen peroxid was very much weaker than in the beginning, and after fifty minutes no reaction at all was obtained. This shows that even in a dilution of 1:50,000 the crude enzym was still very active. In the control case, where the solution of the enzym was boiled for a second, the reaction for hydrogen peroxid did not decrease to any noticeable degree within the same length of time.

While catalase attacks hydrogen peroxid very readily, the hydrogen peroxid also has, when applied in moderate concentration, a directly

[1] The test was made with iodide of potassium, starch, and a trace of ferrous sulphate.

oxidizing influence upon the enzym. This accounts for the rapid decrease of the amount of oxygen developed and for the fact that a point is reached comparatively soon where the enzym becomes entirely inactive. Sweated tobacco, 0.1 gram of which developed 32 cc. of oxygen in fifteen minutes when suspended in a mixture of 10 cc. water with 5 cc. hydrogen peroxid, did not develop any more after the same quantity had been left for fifteen hours in contact with 25 cc. of the same mixture. It may safely be assumed that the detrimental effect of hydrogen peroxid is diminished very much by high dilution.

The activity of β-catalase increases up to a temperature of about 40° C. With further elevation of the temperature the oxidizing action of hydrogen peroxid upon the enzym becomes more powerful than the catalytic action of the enzym upon the hydrogen peroxid, and the enzym very soon loses its activity. A solution was prepared of 0.2 per cent crude β-catalase obtained from sweated tobacco in the manner above described. Thirty cc. of this solution were heated to determined temperatures, and after addition of 5 cc. of hydrogen peroxid of 20° C. the time required for the development of a certain volume of oxygen was noted. At 50° and 60° C. the action was energetic for one minute only, after which it slowed down rapidly and stopped.

Effect of heat on action of β-catalase.

Temperature.	Duration of test.	Volume of oxygen.	Remarks.
° C.	*Minutes.*	*cc.*	
20.....	5½	40	
40.....	3¼	40	
50.....	4	29	Action stopped after 4 minutes.
60.....	2	23	Action stopped after 2 minutes.

GENERAL BEHAVIOR OF α- AND β-CATALASE.

Both the soluble and the insoluble catalase resist the effects of time longer than the ordinary oxidases, as has already been mentioned. The writer examined leaves of various species of *Solanum*, collected in 1841, 1848, 1853, and 1868 (preserved as herbarium specimens), and observed in all of these the production of oxygen upon the addition of hydrogen peroxid. The leaves were first soaked in a little water before the hydrogen peroxid was added. The leaves collected in 1841, however, showed only a weak action.

In an aqueous solution, free from bacteria, β-catalase loses its power either by self-oxidation or by changes within the molecule by atomic migration, but this change is also sometimes relatively slow. Once, however, the writer observed this enzym in a six-months-old culture of *Bacillus pyocyaneus*, in which growth of the germ had apparently stopped for several months.

In aqueous solution the β-catalase is chemically changed to an inac-

ive substance on heating to from 71° to 75° C. The degree of temperature at which the enzym is "killed" depends upon the time of exposure. At 72° C. more than fifteen minutes are required, while a much shorter time suffices at 74° C. Heating but for a second to 75° is not sufficient to kill all the enzym in a neutral solution, but it will injure a great part of it. In a very weak alkaline solution the killing temperature is raised several degrees, but the contrary is true when this alkaline reaction is increased still a little more. In slightly acidulated solutions the killing temperature is lower than in neutral ones.

The killing temperature of α-catalase is about the same as that of β-catalase. Green tobacco leaves were crushed and the juice expressed through flannel. This turbid liquid of acid reaction was passed through a filter, and the filter content, rich in α-catalase, suspended in water and heated to various temperatures. Heating for ten minutes to 60° C. did not decrease the intensity of the catalytic power, but heating for five minutes to 71° C. injured it considerably. After heating for five minutes to 75° C. and cooling quickly a faint trace of that power was still observed, but no trace was noticeable after heating for one minute to 80°. The filtered liquid in the latter case still contained considerable active peroxidase, another proof that this enzym can not be identified with catalase.

In a dry condition catalase resists heat better than in the presence of water. For example, fermented tobacco leaves when heated for two hours to 100° C. had not completely lost their content of α- and β-catalase, although it was very much decreased. A prolonged application of heat, however, kills these enzyms at 80° C., even in the absence of water, as may be inferred from the inactivity of fire- and flue-cured tobacco (cigarette tobacco). Various samples of such products were tested, and in most cases no trace of either α- or β-catalase could be observed.

EFFECT OF MECHANICAL MOTION ON THE REACTION WITH HYDROGEN PEROXID.

It is remarkable to what extent the action of the soluble catalase is promoted by shaking the mixture. One out of many of the observations may be mentioned here. A cold-prepared aqueous extract of sweated tobacco (20 cc.) was mixed with half its volume of hydrogen peroxid and the flask left untouched. In the control case the flask was continuously shaken. The amount of oxygen developed in thirty minutes, not shaken, was 24 cc.; shaken, was 51 cc. The oxygen developed under the influence of mechanical motion was therefore more than double the amount obtained when the flask was left undisturbed.[1]

[1] It hardly needs to be mentioned that in all experiments described in this paper the mixtures with hydrogen peroxid were frequently shaken during the observations in order to obtain the full reaction. Heating the mixtures was never resorted to; on the contrary, any rise of temperature was avoided.

BEHAVIOR TOWARD VARIOUS SALTS.

A careful distinction should be made here between the relation of a salt to the enzym itself and the influence of a salt upon its activity alone. This activity can be stimulated or retarded without the enzym itself being changed in its chemical nature. Salts of a strong acid or alkaline reaction will of course injure the enzym itself, while salts of neutral reaction will probably not do so. Thus, α-catalase is not injured in one day by a 10 per cent solution of magnesium sulphate, nor in five hours by a 5 per cent solution of sodium sulphate, nor in twenty hours by a 2 per cent solution of potassium persulphate,[1] nor in one day by a saturated solution of ammonium sulphate. After these salts are removed by careful washing the α-catalase contained in sweated tobacco is found fully preserved, or very nearly so. It is very probable that β-catalase is more easily injured, but nevertheless it can even be salted out by saturation of its solution with ammonium sulphate without immediate loss of power, although the subsequent drying at the ordinary temperature with the adhering salt leads to a partial loss of its activity.

A concentrated extract was prepared at the ordinary temperature from sweated tobacco (Connecticut crop of 1899) rich in α- and β-catalase, and containing no oxidase and only a trace of peroxidase. Ten cc. of this extract were mixed with 20 cc. of hydrogen peroxid (added in two doses), and in five minutes 160 cc. of oxygen were developed. By saturation with ammonium sulphate a brown-colored precipitate of great catalytic energy was obtained, while the filtrate showed only a trace of activity. After being collected on a filter and dried for twenty-four hours at the ordinary temperature on a porous plate, the precipitate weighed 2.85 grams, more than half of which, however, consisted of adhering ammonium sulphate. Half a gram of this powder dissolved in 20 cc. of water in five minutes developed 223 cc. oxygen, and in fifteen minutes 449 cc.[2]

The considerable depression of the catalytic activity of β-catalase by nitrates is very remarkable. The enzym itself does not seem to be injured materially, as several tests have shown. For example, a very small quantity of a β-catalase preparation, obtained by salting out a cold-prepared concentrated tobacco extract with ammonium sulphate, was kept in a 10 per cent solution of potassium nitrate for twenty-

[1] It might be supposed that this salt would exert an oxidizing action detrimental to the enzym, but such indifferent behavior of the salt has been noticed in other cases also; for example, toward certain aniline colors. (Proscher, Chem.-Zeitung, March, 1900.) Potassium persulphate easily oxidizes hydroquinone to quinone, α-naphthylamine to the blue oxynaphthylamine, and behaves in its oxidizing property like ferric chlorid.

[2] The observation of Jacobson that the "catalytic power" of a pancreas extract, or of an emulsion of almonds, is lost by saturation with sodium sulphate, is probably due to his drying the salted-out product at a higher temperature.

four hours, again salted out by ammonium sulphate, and washed well by a concentrated solution of this salt. Upon redissolving it in 20 cc. water and adding 10 cc. hydrogen peroxid, it still developed 92 cc. oxygen in fifteen minutes, while in the control case 98 cc. were obtained; hence the enzym itself is not injured by potassium nitrate.

The depressing influence of nitrates is seen from the following test: Two portions of an extract of sweated tobacco received an addition of 5 per cent potassium nitrate and 5 per cent magnesium sulphate (cryst.), respectively. Immediately afterwards 20 cc. of each of these liquids were mixed with 10 cc. hydrogen peroxid. The result was:

Oxygen developed in five minutes.

	cc.
In presence of potassium nitrate[1]	15
In presence of magnesium sulphate	88
Control	105

Nitrates have no such depressing influence upon the corresponding action of finely divided platinum. A mixture was prepared of 5 cc. hydrogen peroxid, 20 cc. water, 2 grams potassium nitrate, and a trace of platinum black. Here 28 cc. oxygen were developed in fifteen minutes, while in the control case 31.6 cc. were evolved. This shows that the contact of the nitrate with the enzym itself can be the only cause of the retardation just mentioned.

In some other tests the time necessary to develop a certain volume of oxygen was observed. One gram of crude β-catalase, prepared by salting out a concentrated extract of sweated tobacco and drying at the ordinary temperature, was dissolved in 500 cc. water. To different portions, each containing 5 cc., of this highly diluted solution, 20 cc. water and 0.5 gram of various salts were added. After a further addition of 5 cc. of nearly neutral hydrogen peroxid the time necessary for the production of 40 cc. of oxygen was observed. The mixture was frequently shaken. The number of minutes required to produce 40 cc. of oxygen in the presence of various salts was as follows:

	Minutes.
With sodium chlorid	4¾
With potassium chlorid	4¾
With dipotassium phosphate	4¾
With potassium nitrate	8½
With sodium nitrate	6½
With ammonium nitrate	10½
With calcium nitrate	3¾
Without addition of salts—control	4½

While in this case the mixtures had a weak acid reaction, they had in the following experiment a weak alkaline reaction. The enzym, furthermore, was applied in double the concentration used before, and, with one exception, the amount of salts applied was increased to

[1] The depression of the catalytic power of pancreas and almond extract by potassium nitrate was also observed by Jacobson in 1892.

2 grams. Here the time required to produce 48 cc. of oxygen under otherwise the same conditions as before was noted.

The number of minutes required to produce 48 cc. of oxygen in the presence of various salts was as follows:

	Minutes.
With sodium chlorid	3
With potassium chlorid	3¼
With potassium nitrate	4½
With sodium sulphate	3
With potassium sulphate	4
With sodium carbonate (0.5 gram)	2
With sodium carbonate (2 grams)	4¼
Without addition of salts—control	3

It will be noticed that potassium salts retard the reaction more than sodium salts, and that the nitrates of the alkali group retard more than the other salts. In general, the increase of the amount of any salt has a retarding influence, other things being equal, and it was found in a special case that saturation of the liquid with sodium chlorid retarded the action of the enzym so as to require more than double the time to produce the given amount of oxygen.

Sodium carbonate (anhydr.) attacks *β*-catalase but very slowly even in a 3 per cent solution. Even after fifteen hours at low temperature the enzym is only partially killed. To a solution of which 20 cc. produced 17.8 cc. of oxygen in fifteen minutes, 5 per cent of its bulk of sodium carbonate (anhydr.) was added in the form of a concentrated solution. After standing fifteen hours at 0° C. it was neutralized with acetic acid and, after the removal of the carbon dioxid by a current of air, 5 cc. hydrogen peroxid were added. There were still produced 7.2 cc. oxygen in fifteen minutes. More injury is caused by heating the solution for one minute with 2 per cent of sodium carbonate to 40° C, only 5 cc. oxygen being produced afterwards in fifteen minutes. Scarcely any injury is observed after fifteen hours' contact at 15° C. with a 1 per cent solution of sodium carbonate, and even after standing at the ordinary temperature for three days there is still considerable active enzym present in the solution.

No injury whatever is caused in twenty-four hours by a 2 per cent solution of sodium fluorid or by a 5 per cent solution of dipotassium oxalate. Neither a 5 per cent solution of potassium sulpho-cyanide nor of thio-urea has any apparent injurious influence upon the *β*-catalase. The presence of these compounds seriously interferes, however, with the reaction of the enzym upon hydrogen peroxid, since potassium sulphocyanide is rapidly oxidized by hydrogen peroxid to monopotassium sulphate and prussic acid,[1] while thio-urea is transformed into sulphuric acid and (partly) carbamide.[2] These mixtures rapidly

[1] $KCNS + 3H_2O_2 = KHSO_4 + HCN + 2H_2O$.

[2] $CSN_2H_4 + 4H_2O_2 = SO_4H_2 + CON_2H_4 + 3H_2O$.

assume a very acid reaction. In the latter case a considerable rise of temperature is noticed.[1]

BEHAVIOR TOWARD MERCURIC CHLORID.

Two grams of cured tobacco containing α- and β-catalase were left two days in 2 cc. of a 0.1 per cent solution of mercuric chlorid. While the filtrate showed no reaction whatever on hydrogen peroxid, the insoluble part still showed a slight reaction. Suspended in 30 cc. water, it yielded on addition of 10 cc. hydrogen peroxid:

Oxygen in thirty minutes.

	cc.
After treatment with $HgCl_2$	6
Control	158

This reveals a highly injurious influence of mercuric chlorid on both kinds of catalase. The β-catalase of one gram of the sample yielded 16.5 cc. oxygen in thirty minutes. Hence, even on the assumption that all β-catalase had been merely precipitated by the mercuric chlorid and thus withdrawn from the solution, and further assuming that it was in the first place the α-catalase that had been killed by that salt, an injury due to β-catalase would still be evident.

Catalase is probably also injured by various salts of other heavy metals, but the results obtained upon addition of hydrogen peroxid to such mixtures would be misleading, since many salts of these metals themselves bring on decomposition of hydrogen peroxid.

BEHAVIOR TOWARD ACIDS AND BASES.

It is a noticeable fact that while highly dilute acids retard the action of α- and β-catalase, dilute alkaline solutions promote it. In one case it was shown that on addition of 1 per cent sodium carbonate to a mixture of 10 cc. cold-prepared tobacco extract with 10 cc. hydrogen peroxid, 165 cc. of oxygen were developed in five minutes, while it took fourteen minutes to develop the same amount of oxygen when sodium carbonate was absent.

When the amount of acids in the solutions reaches more than 0.5 per cent, the α- and β-catalase are very soon killed. The following observations may be mentioned: Two grams of finely powdered sweated tobacco were shaken with 40 cc. of a 2 per cent solution of oxalic acid and the mixture neutralized after thirty minutes, with caustic soda. The catalytic power was entirely destroyed. No trace of oxy-

[1] Jacobson's inferences as to the injurious influence of potassium sulpho-cyanide upon the "catalytic property of diastase, emulsin, etc.," must be corrected accordingly, since it is the acid reaction of mono-potassium sulphate formed by the hydrogen peroxid which interferes with the result, and not the sulpho-cyanide as such. Furthermore, it is not diastase and emulsin, but a separate enzym, that causes the "catalysis of hydrogen peroxid" as here set forth.

gen was developed either by the extract or by the residue. In a second test, solutions of 0.2 per cent oxalic and sulphurous acids were permitted to act for eighteen hours under the same conditions mentioned above. The β-catalase was almost entirely destroyed and the α-catalase was also considerably injured.

The number of cubic centimeters of oxygen developed by α-catalase in thirty minutes was as follows:

	cc.
Control	158
With 0.2 per cent oxalic acid	33
With 0.2 per cent sulphurous acid	28

A solution of 0.1 per cent acetic acid at the ordinary temperature did not injure the catalytic power in one hour, but injured it gradually at a temperature of 55° C.

When sweated tobacco was suspended in fifty times its weight of a 2 per cent sulphuric acid solution the catalytic power was destroyed in fifteen minutes.[1] A solution of β-catalase lost its activity in fifteen minutes after the addition of 1 per cent sulphuric acid. α-catalase behaves the same, as was shown on suspending tobacco in fifty times its weight of 1 per cent sulphuric acid.

Saturated baryta water kills β-catalase in two days, but only slowly injures α-catalase, as shown[2] in an experiment with 2 grams cured tobacco suspended in twenty-five times its weight of baryta water. After neutralization with acetic acid and addition of 5 cc. hydrogen peroxid, the amount of oxygen developed in 15 minutes was as follows:

	cc.
α-catalase	33
β-catalase	0
Control to β-catalase	89

Sodium hydrate in a dilution of 1 per cent kills α- and β-catalase almost instantly, while a dilution of 0.1 per cent has no injurious influence, at least not within a short time.

BEHAVIOR TOWARD ALCOHOL.

Absolute alcohol injures neither α- nor β-catalase at the ordinary temperature in twenty hours. One gram of sweated tobacco was mixed with 10 cc. absolute alcohol.[3] The alcohol was filtered off

[1] It may here be mentioned that in all such cases the liquid was neutralized with dilute caustic soda before the hydrogen peroxid was added. An excess of the dilute acid had to be applied, since the tobacco often contains 10 per cent and over of salts of organic acids (malic, citric, oxalic acids).

[2] Of course a small part of the dissolved baryta was rendered inactive by combination with the acids bound to the ammonia and nicotine contained in the tobacco, but this fact, considering the large amount of baryta water, does not essentially alter the above inference.

[3] While absolute alcohol does not dissolve a trace of the enzym, alcohol of a strength of 50 per cent dissolves a considerable amount.

after twenty hours and the tobacco powder, after being freed as much as possible from the adhering alcohol by pressure between filter paper, was extracted with 20 cc. water for three hours at the ordinary temperature. The filtrate, as well as the undried residue, yielded almost exactly as much oxygen in fifteen minutes as was obtained in the control case, showing that alcohol does not act injuriously on the enzym, at least not within a short time.

A concentrated cold-prepared extract of sweated tobacco was mixed with one-tenth of its volume of alcohol and left in a filled, well-stoppered flask for five days in a dark box at a temperature of from 15° to 18° C. There was no indication of bacterial growth. Twenty cc. of this liquid gave in ten minutes 37 cc. oxygen, while in the control case 50 cc. were originally obtained. The action of catalase on hydrogen peroxid is not influenced by the presence of small quantities of alcohol, but larger quantities—above 30 per cent—exert a retarding influence, especially noticeable when the amount of catalase present is but small.

The action of boiling absolute alcohol is of some interest. One gram of sweated tobacco was kept for half a minute in boiling absolute alcohol and then, after the removal of most of the alcohol by pressure between filter paper, extracted with cold water. Upon addition of 10 cc. hydrogen peroxid to the filtrate, as well as to the residue suspended in 20 cc. water, the following results were obtained:

Cubic centimeters of oxygen developed in twenty minutes.

	By α-catalase.	By β-catalase.
Treated	55	3
Control	70	20

The remarkable fact that boiling absolute alcohol does not instantly kill the enzym is probably due in part to the fact that all enzyms resist a higher temperature in the absence of water than when dissolved in water, and also to the fact that alcohol boils at a comparatively low temperature.

BEHAVIOR TOWARD CHLOROFORM.

A concentrated aqueous extract of sweated tobacco was left with some chloroform for five days in a dark box. Then, after the evaporation of the chloroform at the ordinary temperature, 20 cc. of the liquid were mixed with 6 cc. of hydrogen peroxid. In ten minutes the volume of oxygen obtained was:

	cc.
Treated	48
Control[1]	54

[1] The control test was made with an equal amount of the same extract before the experiment was begun.

After standing twelve days another portion of the same extract had lost considerably more of its catalytic power, only 14.5 cc. of oxygen being developed in the same time.

In another trial sweated tobacco was first exhausted with water to remove all β-catalase and then left in chloroform water at the ordinary temperature for four weeks. It still showed a moderate reaction upon hydrogen peroxid, showing that some α-catalase was still present. No β-catalase had here been formed from the insoluble catalase.

The action of catalase upon hydrogen peroxid is not influenced in a marked degree by the presence of a little chloroform or ether.[1]

BEHAVIOR TOWARD PHENOL.

To an extract of sweated tobacco rich in β-catalase was added 0.2 per cent phenol, but after twenty-four hours' contact not the least decrease of catalytic power was observed. In another case the extract was completely saturated with phenol, and thus contained 6.6 per cent of it, but here every trace of catalytic power was annihilated after twenty hours.

The presence of 1 per cent phenol retards the action of the enzym. One-tenth gram of crude catalase was dissolved in 30 cc. water, and 10 cc. of this solution yielded, on addition of 5 cc. hydrogen peroxid, 25 cc. oxygen in fourteen and one-half minutes when 1 per cent phenol was present, while in the absence of the latter it took only eleven and one-half minutes to develop the same volume.

BEHAVIOR TOWARD VARIOUS OTHER REAGENTS.

The inquiry as to the nature of the activity of enzyms led the writer years ago to the assumption that in their molecules there are certain unstable atomic groupings (labil atomic groups). Such groups are on the one hand able to transform heat energy into chemical energy, and on the other hand are readily changed by atomic migration under the influence of an increased temperature or powerful compounds, such as acids, etc. The writer has expressed the view that the instability as well as the activity of enzyms might be due to the simultaneous presence of amido and aldehyde groups. In regard to the labil amido groups, their presence was rendered probable by the destructive action which formaldehyde exerts upon the power of the enzyms. As to the presence of aldehyde, or also of ketone groups, no convincing reactions could be obtained, but it remains still to be seen whether there are not aldehyde groups present in a less reactive polymerized form. The following tests with catalase were made, to characterize the labil groups:

[1] According to Jacoby, chloroform acts as a stimulant on the activity of certain oxidizing enzyms (Virchow's Archiv. vol. 157), and according to Vogel (1897) very small doses of various ethers stimulate the cellular respiration.

ACTION OF FORMALDEHYDE.

Fifty cc. of a weak alkaline solution of α-catalase were mixed with 10 cc. commercial formalin[1] previously neutralized. Of this mixture 20 cc. were immediately mixed with 5 cc. hydrogen peroxid, the amount of oxygen developed in ten minutes being as follows:

	cc.
After action of formaldehyde	3
Control	52

A diluted solution of β-catalase was mixed with 10 per cent of neutralized formalin, causing the formation of some precipitate. After twenty minutes 20 cc. were mixed with 5 cc. hydrogen peroxid and still 1 cc. oxygen was obtained, but after standing one hour no trace was produced. In the control case 44 cc. were developed in ten minutes.

ACTION OF NITROUS ACID.

Neither α-nor β-catalase is injured by a 5 per cent solution of sodium nitrite at the ordinary temperature within one day, provided the solution is neutral or weakly alkaline, but as soon as the mixture is acidulated the enzym is injured by the nitrous acid liberated.

A special test showed that 0.4 per cent free nitrous acid injured the enzym considerably in one day. One-tenth gram of crude catalase was dissolved in 100 cc. water. Chloroform was then added and the solution shaken and divided into three equal parts. One part received no addition. The second part received an addition of 0.2 gram of acetic acid, and the third part 0.2 gram of acetic acid and 0.22 gram of sodium nitrite. After standing one day these solutions were made slightly alkaline before 5 cc. of hydrogen peroxid were added. The volumes of oxygen developed in 1½ minutes were:

	cc.
Control	40
After treatment with acetic acid	8.4
After treatment with nitrous acid	2.5

The loss of activity under the influence of formaldehyde or of nitrous acid renders the supposition very probable that labil amido groups are concerned in the activity of the enzym, since labil amido groups are very readily acted upon, even in neutral and highly dilute solutions, by those compounds.[2] Here we have before us a specific action, while the loss of activity under the influence of hydrochloric, sulphuric, or

[1] The preparation contained about 40 per cent pure formaldehyde and had only a slightly acid reaction. It may be mentioned that this aldehyde in dilute and neutral solution is acted upon but slowly by hydrogen peroxid; hence this influence can be neglected here.

[2] The detrimental action of mercuric chlorid above mentioned might most easily be explained by the reaction of this salt upon labil amido groups in which hydrogen can easily be replaced by mercury. By such a chemical change of an active atomic group the activity of the enzym itself is inhibited or destroyed.

oxalic acids indicates merely the loss of lability by atomic migration without giving a decided answer as to the nature of the labil atomic groups themselves.

The next question to be considered is: By what other groups in the molecule is the lability of those amido groups induced? The following tests do not give a satisfactory answer to this question, but seem to indicate that neither ordinary aldehyde nor ketone groups are the cause. The supposition as to the presence of polymerized aldehyde groups, however, still remains to be considered, especially the detrimental action of free hydroxylamine, which might be explained by a dismemberment of a polymeric aldehyde group and subsequent reaction with the hydroxylamine.

ACTION OF PRUSSIC ACID.

One gram of tobacco containing α- and β-catalase was mixed with 20 cc. of dilute (2 per cent) prussic acid and the liquid was filtered after two hours. Ten cc. hydrogen peroxid were added to the filtrate, but no trace of oxygen was obtained. In the control case, however, 20.2 cc. of oxygen were developed in fifteen minutes. The residue in the filter was also tested after washing, but here the full original power—60 cc. of oxygen in fifteen minutes—was observed. In a second experiment the same dilute prussic acid was allowed to act on the tobacco for twenty hours, and the filtrate was then tested for the catalytic power after the prussic acid had evaporated at the ordinary temperature, but no trace of oxygen was now developed after addition of hydrogen peroxid. The α-catalase in the residue had in this case also preserved the full catalytic power. It would seem, therefore, that while β-catalase is easily killed by prussic acid α-catalase shows considerable resistance, at least as long as it is present in the undissolved state. In weak alkaline solution the result differs, inasmuch as considerable injury is caused to α-catalase by prussic acid.

A regeneration of the activity after evaporation of the prussic acid is only observed with β-catalase when the amount of prussic acid permitted to act upon it has been very small.

BEHAVIOR OF α-CATALASE TOWARD HYDROGEN SULPHID.

Two grams of finely pulverized sweated tobacco were suspended in 500 cc. of water and hydrogen sulphid passed through until complete saturation was obtained. The liquid was allowed to stand for twenty-four hours. The tobacco was then collected on a filter and after being washed well was suspended in 30 cc. of water, and 10 cc. of hydrogen peroxid added. In thirty minutes the volume of oxygen developed was 170 cc., while in the control case, after extracting the tobacco (2 grams) well with cold water, it was 609 cc. This shows

that although hydrogen sulphid injures the α-catalase at the ordinary temperature, this injury proceeds but slowly.

Schœnbein reports[1] that plant juices instantly lose their catalytic power upon coming in contact with hydrogen sulphid, but the above test shows that this power is not so easily destroyed, after all.

A second test yielded essentially the same result. In both cases a considerable amount of sulphur was set free, leading to the inference that catalase probably promotes the oxidation of H_2S by the oxygen of the air.

BEHAVIOR TOWARD HYDROXYLAMINE.

One gram of hydrochlorid of hydroxylamine[2] dissolved in a little water was neutralized with sodium carbonate, and the solution diluted to 20 cc. After the addition of 1 gram of sweated tobacco the mixture was allowed to stand for eighteen hours. The filtrate was now found to have completely lost every trace of catalytic power. This was not the case, however, with the insoluble portion, which, after washing and suspending in 20 cc. of water with the addition of 10 cc. hydrogen peroxid, developed 29 cc. oxygen in fifteen minutes. In the same length of time 62 cc. were obtained in the control case.

BEHAVIOR TOWARD PHENYLHYDRAZINE.

A concentrated cold-prepared extract of sweated tobacco[3] was salted out with ammonium sulphate, the precipitate pressed between filter paper, dissolved in a little water, and some phenylhydrazine acetate added. After twenty-four hours a small amount of precipitate was formed, which yielded some oxygen gas with hydrogen peroxid, while the filtrate gave only traces. It therefore seems that β-catalase forms a still somewhat active compound with phenylhydrazine. This, however, requires further study.

In testing α-catalase, a weak alkaline solution was mixed with some phenylhydrazine acetate. After twenty-four hours a precipitate was formed, but the amount was insignificant. The clear filtrate, upon the addition of 5 cc. hydrogen peroxid, in ten minutes yielded 11 cc. oxygen, while in the control case 52 cc. of oxygen were obtained. One would naturally suppose that if ketone or ordinary aldehyde groups were present the enzymic activity would be totally destroyed in a short time.[4]

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[1] Journ. prakt. Chem., 1863, p. 340.

[2] This salt has a strong acid reaction, hence experiments made directly with it are not conclusive. The acid reaction has to be removed, since it alone would suffice to injure or kill the enzym.

[3] Prepared with the addition of 10 per cent alcohol to prevent bacterial development.

[4] Emulsin also preserves its powers after it has been in contact with phenylhydrazine acetate for twenty-four hours. It can be precipitated with alcohol and still exhibit its action on amygdalin.

BEHAVIOR TOWARD ALKALINE SILVER SOLUTION.

A very subtile reagent for aldehyde groups is prepared by adding a few drops of dilute caustic soda to an ammoniacal silver solution which contains only a small excess of ammonia. Such a solution, containing 2 per cent silver oxid, was added to 20 cc. of the α-catalase solution above mentioned. After standing twenty-four hours a very small amount of dark sediment was formed, but the solution still had its original degree of catalytic power. A considerable separation of metallic silver and a destruction of the catalytic power would naturally have been expected were ordinary aldehyde groups concerned in the activity.

In a second test freshly precipitated silver oxid was suspended in 40 cc. of a solution of crude β-catalase (obtained by salting out tobacco extract with sodium sulphate) and the mixture tested after standing at the ordinary temperature for two days. To this and the control solution were added several drops of ether. In testing both solutions at the same time, it was found that while 20 cc. of the control solution, after the addition of 10 cc. hydrogen peroxid, developed 53 cc. of oxygen in two minutes, the filtrate from the silver oxid took three minutes to do the same; hence the injury caused by silver oxid was only moderate.

GENERAL OCCURRENCE OF α-AND β-CATALASE.

Numerous tests have established beyond a doubt that catalase is of general occurrence in the vegetable kingdom. No living plant or vegetable organ tested was found free from it, some of the plants containing more of the soluble and others more of the insoluble form. Leaves from various plant families showed principally the insoluble catalase, in some cases only slight traces of the soluble kind being noticeable, while in various seeds the soluble kind was found present in larger proportions.

Healthy green tobacco leaves, taken from the greenhouse on December 22, were dried at 40° C. After being ground to a fine powder 2 grams were extracted with 40 grams of water for three hours at the ordinary temperature. The filtrate gave reactions for oxidase and peroxidase, but showed no catalytic power on hydrogen peroxid, and therefore contained no β-catalase.[1] The well-washed residue, suspended in 20 cc. water, developed, after the addition of 12 cc. hydro-

[1] Traces of β-catalase may be observed, however, when the green tobacco leaves have not been dried, but are ground and expressed in the fresh state, the clear filtrate being directly tested. It must be borne in mind, however, that the frequent presence of nitrates in the leaves may decrease the action on hydrogen peroxid to a considerable extent, which might lead sometimes to the inference of the presence of only very small quantities of β-catalase.

en peroxid, 107.2 cc. oxygen in fifteen minutes, and was relatively ich in α-catalase. The stalk of the tobacco plant is about as rich in his enzym as the leaves, but the fine roots contain less. Only one comparative test was made on this point, however. In the flowers (air dry) of the tobacco plant hardly any β-catalase is found, but considerable α-catalase.

Besides Phanerogams from different families, ferns, mosses, liverworts, and higher and lower algæ, as well as fungi, were also tested with positive results. It may be mentioned that vegetable cells die quickly in a 0.5 per cent solution of hydrogen peroxid, while their catalase is much more slowly injured.

Suitable data which would allow the investigator to calculate the absolute weight of catalase from a certain volume of oxygen developed in a given time and at neutral reaction are thus far not known; hence the volumes of oxygen given off by different objects can have only a relative value, serving for purposes of comparison. This is also the reason why these volumes were not reduced to normal pressure and 0° C.[1] The following tests with leaves, fruits, and seeds were carried on at the request of the writer by Mr. D. W. May. Eight grams of the leaves in the fresh state were crushed to a pulp, with the aid of a little sand and water, before the hydrogen peroxid was added, while two grams of the seeds in the air-dried state were finely pulverized, shaken up with 50 cc. of water, and the mixture left in the ice box overnight for extraction. The filtrates were gradually mixed with 5, 10, or even more cubic centimeters of hydrogen peroxid, as the degree of activity in special cases demanded, while the washed residue was suspended in from 50 to 60 cc. water before the hydrogen peroxid was added.

Cubic centimeters of oxygen developed by different leaves.

	5 minutes.	10 minutes.	15 minutes.	20 minutes.	25 minutes.
Magnolia (Magnolia sp.)	47	92	129	163	.....
Holly (Ilex sp.)	50	95	129	.....	.....
Clover[2] (Trifolium repens)	98	129	176	218	.....
Cotton (Gossypium herbaceum)	49	102	157	209	.....
Rose[2] (Rosa sp.)	52	106	156	202	252
Spruce (Picea sp.)	56	107	148	.....	.....

[1] It may be mentioned, however, that the temperature of the laboratory ranged generally from 16° to 22° C. and the barometric pressure from 746 to 771 mm.

[2] Clear filtrates of the diluted juices of the leaves of rose and clover were also prepared and tested but β-catalase was absent.

Cubic centimeters of oxygen developed by various seeds.

		Minutes.			
		5.	10.	15.	2..
GRAMINEÆ:					
Sweet corn (Zea saccharata)	Filtrate...	99.0	150.0	.....	1
	Residue ..	38.0	52.0	59.0	.....
Barley (Hordeum sativum)	Filtrate...	9.0	14.0	17.0	.....
	Residue ..	20.0	32.0	42.0	.....
Rye (Secale cereale)	Filtrate...	8.0	11.4	14.0	.....
	Residue ..	12.5	17.0	20.0	.....
Wheat (Triticum sativum)	Filtrate...	4.4	7.0	9.6	.....
	Residue ..	6.5	9.2	11.0	.....
Wheat (Calif.) (Triticum sativum)	Filtrate...	9.0	14.0	18.0	.....
	Residue ..	13.1	20.1	24.0	.....
Millet (Chaetochloa italica)	Filtrate...	24.0	39.0	62.0	79
	Residue ..	18.0	25.0	31.0	36
CRUCIFERÆ:					
Black mustard (Brassica nigra)	Filtrate...	3.0	3.0	.....	.....
	Residue ..	9.5	12.7	14.0	.....
White mustard (Brassica alba)	Filtrate...	3.2	3.5	.....	.....
	Residue ..	4.8	8.0	11.0	.....
Turnip (Brassica rapa)	Filtrate...	1.0	1.7	.....	.....
	Residue ..	98.0	121.0	125.0	.....
Radish (Raphanus sativus)	Filtrate...	2.0	2.4	2.6	.....
	Residue ..	62.0	79.0	87.0	.....
Rape (Brassica napus)	Filtrate...	1.0	1.0	.....	.....
	Residue ..	66.0	90.0	103.0	.....
LEGUMINOSÆ:					
Peas (Pisum sativum)	Filtrate...	16.0	19.0	21.0	.....
	Residue ..	3.6	4.0	4.2	.....
Beans (Phaseolus vulgaris)	Filtrate...	62.0	82.0	96.0	.....
	Residue ..	20.0	28.0	35.0	.....
Lentils (Lens esculenta)	Filtrate...	8.2	10.2	11.2	.....
	Residue ..	18.0	24.0	26.0	.....
Lupins (Lupinus luteus)	Filtrate...	44.0	60.0	70.0	.....
	Residue ..	61.0	79.0	89.0	.....
Clover (Trifolium repens)	Filtrate...	107.0	170.0	214.0	.....
	Residue ..	100.0	162.0	221.0	.....
Alfalfa (Medicago sativa)	Filtrate...	48.0	58.0	63.0	.....
	Residue ..	67.0	108.0	130.0	.....
VARIOUS FATTY SEEDS:					
Cotton (Gossypium herbaceum)	Filtrate...	112.0	112.5	.....	.....
	Residue ..	75.0	101.0	103.0	.....
Flaxseed (Linum usitatissimum)	Filtrate...	59.0	88.0	96.0	.....
	Residue ..	66.0	90.0	95.0	.....
Sunflower (Helianthus annuus)	Filtrate...	84.0	104.0	121.0	.....
	Residue ..	109.0	159.0	172.0	.....
Poppy (Papaver sp.)	Filtrate[1]..	72.0	132.0	194.0	.....
	Residue ..	92.0	150.0	203.0	.....
MISCELLANEOUS SEEDS:					
Tobacco (Nicotiana tabacum)	Filtrate...	50.0	70.0	81.0	.....
	Residue ..	32.0	45.0	54.0	.....
Beet (Beta vulgaris)	Filtrate...	25.0	30.0	32.0	.....
	Residue ..	24.0	31.0	33.0	.....
Squash (Cucurbita sp.)	Filtrate...	79.0	91.0	96.0	.....
	Residue ..	33.0	44.0	49.0	.....
Pumpkin (Cucurbita pepo)	Filtrate...	96.0	142.0	167.0	.....
	Residue ..	64.0	88.0	96.0	.....
Peach (Prunus persica)	Filtrate...	50.0	108.0	132.0	.....
	Residue ..	178.0	214.0	226.0	.....
Almonds (Prunus amygdalus)	Filtrate...	22.0	36.0	48.0	.....
	Residue ..	5.5	7.5	9.5	.....
Chestnut (Castanea americana)	Filtrate...	68.0	99.0	116.0	117.0
	Residue ..	68.0	89.0	96.0	.....
English walnut (Juglans regia)	Filtrate...	50.0	85.0	89.0	100.0
	Residue ..	85.0	92.0	95.0	.....
Pecan (Hicoria pecan)	Filtrate...	29.0	47.0	62.0	.....
	Residue ..	88.0	103.0	103.0	.....
Filbert (Corylus sp.)	Filtrate...	48.0	73.0	85.0	92.0
	Residue ..	44.0	66.0	80.0	88.0
Butternut (Juglans cinerea)	Filtrate...	15.0	29.0	38.0	.....
	Residue ..	7.0	11.0	14.0	.....
Peanut (Arachis hypogea)	Filtrate...	117.0	123.0	124.0	.....
	Residue ..	72.0	97.0	110.0	.....
Peanut hull	Filtrate...	3.0	5.0	8.0	.....
	Residue ..	6.0	10.0	12.0	.....

[1] This filtrate was not perfectly clear.

Cubic centimeters of oxygen developed by various fruits, etc.

		Minutes.			
		5.	10.	15.	20.
Orange (Citrus aurantium sinensis)	Filtrate...	1.5	1.8	.....	.....
	Residue ..	2.5	2.5	.....	.....
Orange II	Filtrate...	2.0	4.0	.....	.....
	Residue ..	3.0	3.2	.....	.....
Orange peel	Filtrate...	1.8	2.0	.....	.....
	Residue ..	4.0	7.0	9.0	.....
Lemon[1] (Citrus medica limon)	Filtrate...	1.0	1.5	.....	.....
	Residue ..	.6	.8	.....	.....
Lemon peel	Filtrate...	1.0	1.2	.....	.....
	Residue ..	3.2	4.5	.....	.....
Banana (Musa sapientum)	Filtrate...	3.0	3.0	.....	.....
	Residue ..	6.5	10.0	13.0	14.0
Banana peel	Filtrate...	5.0	7.5	10.5	.....
	Residue ..	40.0	72.0	87.0	96.0
Apple, sour (Pyrus malus)	Filtrate...	4.0	4.2	.....	.....
	Residue ..	3.0	3.0	.....	.....
Apple, subacid	Filtrate...	1.0	1.6	.....	.....
	Residue ..	2.2	3.2	3.6	.....
Apple peel	Filtrate...	3.0	3.0	.....	.....
	Residue ..	3.0	5.0	.....	.....
Apple peel, subacid	Filtrate...	2.8	3.8	4.3	.....
	Residue ..	16.0	26.0	34.0	.....
Apple seed[2]	Filtrate...	119.0	180.0	227.0	.....
	Residue ..	110.0	163.0	223.0	.....
Pear (Pyrus communis)	Filtrate...	5.5	7.2	9.4	.....
	Residue ..	20.0	30.0	35.0	.....
Pear peel	Filtrate...	22.0	33.0	42.0	45.0
	Residue ..	62.0	91.0	101.0	104.0
Date (Phœnix dactylifera)	Filtrate...	4.0	7.0	8.0	.....
	Residue ..	10.5	17.5	23.0	.....
Strawberries, sour (Fragaria chiloensis)	Filtrate...	.5	1.0	.....	.....
	Residue ..	.5	1.0	.....	.....
Strawberries, neutralized	Filtrate...	6.0	7.5	.....	.....
	Residue ..	2.0	3.5	.....	.....
Onion, bulb (Allium cepa)	Filtrate...	3.0	5.0	6.5	.....
	Residue ..	21.0	37.0	62.0	.....
Onion leaves	Filtrate...	76.0	97.0	110.0	.....
	Residue ..	91.0	140.0	189.0	.....
Potato flesh (Solanum tuberosum)	Filtrate...	56.0	82.0	92.0	98.0
	Residue ..	52.0	71.0	80.0	85.0
Potato peel	Filtrate...	60.0	82.0	93.0	98.0
	Residue ..	75.0	94.0	101.0	102.0

[1] The lemon juice neutralized by carbonate of soda yielded 5 cc. oxygen in five minutes.
[2] The filtrate from apple seed developed 552 cc. oxygen in forty-five minutes, the residue 379 cc. in thirty minutes.

We learn from these determinations that the flesh of the fruits when of an acid character is poor in catalase and that at the same time the seeds may be very rich in it. Compare, for instance, the above data for apple seed and apple flesh. It is true that a better result is obtained after neutralization of the acid, but even in this case the catalytic power appears small. Compare, also, the data for strawberry and lemon. Evidently the accumulation of acid kills the enzym. We notice further a relatively large amount in the fatty seeds, but in starchy seeds only the sweet corn and chestnut are noticeably rich in catalase. Relatively a very large content of β-catalase is observed with seeds of poppy and clover. Turnip, radish, and rape seed, while rich in α-catalase, are exceedingly poor in β-catalase. During germination the total catalase is very much increased, as observed with barley shoots about 5 cm. long. Twenty grains yielded in twenty minutes 30 cc. of oxygen, while twenty shoots from the same lot yielded fully 130 cc.

In fungi the amount of catalase is relatively very large. Spores of *Penicillium glaucum* were sown in one liter of a sterilized aqueous solution of the following:

	Per cent.
Peptone	0.1
Glucose	.5
Malic acid	.2
Dipotassium phosphate	.1
Magnesium sulphate	.01

After four weeks a large mass of mycelium with spores was developed, which was filtered off. In the clear yellowish filtrate, which now showed a neutral reaction, a considerable reaction for β-catalase was obtained, but none for either oxidase or peroxidase.[1] Of this filtrate three portions of 50 cc. each were taken. The first was mixed directly with 10 cc. of hydrogen peroxid; the second portion only after heating for two minutes at 75° C. and quickly cooling; the third portion after heating to 87° for one minute and allowing to cool slowly. The volume of oxygen developed in fifteen minutes from the first portion was 78 cc., from the second portion only 14.8 cc., while from the third portion no oxygen at all was developed. The washed mycelium, together with the spores, was now left for one hour in 80 per cent alcohol in order to kill the mycelium, which was then pressed gently between filter paper, dried at 40° C., and finely pulverized. Of this product 0.5 gram was again washed well with water, in order to remove all β-catalase, and then suspended in 20 cc. water. Hydrogen peroxid in portions of 10 cc. was now gradually added. The sudden start and sudden stop of the development of oxygen gas was very striking and evidently indicated the presence of a great deal or of a very energetic kind of catalase. When the process had slowed down considerably further addition was stopped. In the short time of forty-one minutes fully 800 cc. of oxygen were developed[2] from 90 cc. of hydrogen peroxid added. It was probably the α-catalase of the mycelium only and not that of the spores of the fungus that caused this considerable development, since the membranes of the latter are impregnated by a fatty substance that admits aqueous solutions to the interior with considerable difficulty.[3]

Another fungus tested was *Pleurotus sapidus*, which proved very rich in β-catalase but less rich in α-catalase. Conidia of a Uredo also showed a very powerful action.

A test for catalase in bakers' yeast yielded the following result: A portion was divided into three equal parts, one part being dried at

[1] A slight blue coloration that set in after half an hour's standing in the test for oxidase (not peroxidase) can hardly be considered as a decisive test.

[2] Barometric pressure 771 mm.; temperature 22° C.

[3] That the accumulation of β-catalase in a liquid is not inimical to bacterial growth was proven with the mold culture filtrates.

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110° C. to determine the dry matter, which was found to be 1.851 grams; another portion, suspended in 25 cc. of water, after the addition of 10 cc. of hydrogen peroxid developed 82 cc. of oxygen in thirty minutes; the third part was left with 100 cc. of a 10 per cent glucose solution for twenty-four hours and, after filtering the fermenting liquid, the filtrate and residue were tested separately. The filtrate gave no reaction with hydrogen peroxid; the residue treated as above gave 108 cc. of oxygen in thirty minutes. This sample of yeast contained no oxidase and but a trace of peroxidase.

Another test was made with fresh beer yeast, the yeast being free from any trace of oxidase and containing only a faint trace of peroxidase. A portion of the yeast was suspended in 100 cc. of water and with frequent shakings the mixture was divided into two equal parts, one part serving for the determination of the dry matter, which was found to be 0.540 gram. The other part was left with 3 cc. of chloroform for twenty-four hours in order that the cells might be killed and consequently give up their enzyms to the water more easily, thus making it possible to determine whether there was any soluble catalase present. This was found to be the case. The clear filtrate gave, upon the gradual addition of 15 cc. of hydrogen peroxid, 117 cc. of oxygen in thirty minutes. The killed yeast itself, however, after washing gave 452 cc. of oxygen in fifteen minutes. This hardly leaves any doubt but that the amount of α-catalase here is larger than the amount of β-catalase. It is noticeable also that the fresh beer yeast is richer in total catalase than bakers' yeast.

Various bacteria also produce considerable catalase,[1] *Bacillus pyocyaneus*, for example; but the amount depends to some extent upon the conditions of nutrition. In a nutrient fluid containing 0.5 per cent peptone and 1 per cent glycerol or cane sugar as organic materials there was much less catalase produced than in a solution containing 1 per cent glycerol, 0.2 per cent tyrosine, and 0.2 per cent sodium acetate, but no peptone.

In the animal kingdom catalase is also of general occurrence. The aqueous extracts of spleen, pancreas, liver, kidney, brain, muscles, and also the blood serum show the power of catalyzing hydrogen peroxid, but certain secretions, as, for example, the urine, lack it. Infusoria, insects, worms, and mollusks were examined also with positive results.

The luminous parts of a lightning beetle do not contain a markedly larger proportion of catalase than other parts of this insect. Different parts of about equal size were crushed with about 10 cc.

[1] Other oxidizing enzyms—oxidase and peroxidase—do not appear to be produced by many bacteria. Cultures of *B. subtilis* and *B. pyocyaneus* did not show them, but according to Roux (Comptes Rend., vol. 128, p. 212, 1899), *B. coli* can produce one of these.

water, and after transferring into an Erlenmeyer flask, 5 cc. hydrogen peroxid were added (rendered previously slightly alkaline). The time necessary to produce 20 cc. and 40 cc. oxygen was then noted. The results were:

Oxygen.	With head.	With upper abdomen.	With luminous parts.
	Minutes.	*Minutes.*	*Minutes.*
20 cc	1¼	1¾	1¼
40 cc	5¼	7¼	5¼

A small beetle of about the size of the head of the lightning beetle produced 40 cc. oxygen in six and one-fourth minutes, while a medium-sized *Carabus*, 0.618 gram in weight, after being crushed with 20 cc. water, produced, upon the gradual addition of 20 cc. hydrogen peroxid, 168 cc. oxygen in four minutes, corresponding to the decomposition of nearly 0.5 gram pure anhydrous hydrogen peroxid.

The extracts[1] of animal organs yield, on saturation with ammonium sulphate, precipitates which, after drying at the ordinary temperature, are only partly soluble again in water. However, not only the soluble portion, but also that which has become insoluble, shows catalytic power. Two-tenths of a gram of the insoluble part of a crude catalase preparation from calf's spleen, when suspended in 20 cc. water, yielded, upon addition of 5 cc. hydrogen peroxid, 29.2 cc. oxygen in twenty minutes. Hence this product contains relatively little of the active principle. An aqueous extract of beef muscles has a high degree of catalytic power, and even after it is heated for one moment to 62° C. and the coagulated albumen is removed the clear filtrate has still a powerful action on hydrogen peroxid, while the coagulum itself gives merely a faint trace of action, showing that it absorbed only traces of catalase. Finely chopped beef extracted for fifteen minutes with twice its weight of water at 40° C. yielded a reddish filtrate of weak acid reaction, of which 20 cc. decomposed 5 cc. of a 3 per cent hydrogen peroxid preparation almost completely in one minute. When rendered slightly alkaline the same amount of filtrate produced, upon addition of 20 cc. hydrogen peroxid, fully 163 cc. oxygen gas in but two minutes.

The presence of α-catalase as well as β-catalase in the pancreatic gland becomes probable from the fact that the pulp shows considerable catalytic power even after repeated extraction with chloroform water. A 1 per cent solution of sodium carbonate at the ordinary temperature, however, extracts the insoluble portion of catalase but slowly, and besides transforms a part of it into β-catalase by its prolonged influence. The hen's egg is an object poor in catalase. Ten cc. of the white of an egg, upon mixture with 5 cc. hydrogen peroxid, yielded

[1] These extracts were prepared by the digestion of the finely chopped organs with at 40° to 50° C. for a short time and filtering.

only 21 cc. of oxygen in fifteen minutes, and the entire yolk yielded only 1 cc.

Milk sometimes contains only traces of catalase. In one case 20 cc. of fresh cow's milk gave, upon the addition of 10 cc. hydrogen peroxid, only 2.4 cc. oxygen in fifteen minutes.[1] In another instance 20 cc. of fresh milk yielded, after the addition of 15 cc. hydrogen peroxid, 9.2 cc. oxygen in the same length of time.[2]

Some observations made by Spitzer[3] with regard to the amounts of oxygen produced by various organs may be added here:

Oxygen developed in—	Dog.				Cattle.	Frog.
	Blood (1 gram).	Liver (1 gram).	Brain (2 grms.).	Muscles (2 grms.).	Pancreas (1 gram).	Ovaries (2 grms.).
	cc.	cc.	cc.	cc.	cc.	cc.
4 minutes	85	65	30.8	22	71	24
13 minutes		76	56	54	82	48

IS CATALASE AN OXIDIZING ENZYM?

The simple fact that catalase energetically decomposes hydrogen peroxid would not in itself justify the inference that catalase is also an oxidizing enzym. Such a deduction has, however, some probability, since we find this catalytic property together with the power of inducing oxidations in one other substance, viz, platinum black. But platinum black furthermore shows the chief characteristic of the ordinary oxidase—that of causing, even in the absence of hydrogen peroxid, a blue reaction with guaiac, which reaction is not obtained with catalase. With platinum black even reducing actions are known,[4] the writer having years ago shown that nitrates are reduced to ammonia by glucose in aqueous solution upon the addition of some very active platinum black.[5] In this process the oxygen of the nitrates is thrown upon the sugar, which is thus converted into acids, while hydrogen from the sugar migrates to the nitrogen of the nitrates, yielding ammonia. This interesting process, which demonstrates that an agency causing oxidations can under other circumstances also cause reductions, seems to have remained unknown to some recent writers, to judge from their peculiar discussions of the reducing actions in the living cells.

[1] Since catalase and other oxidases are not constant concomitants of milk, it might be of interest to compare, in this regard, milk from healthy with that from diseased animals.

[2] The so-called test of Storch to distinguish boiled from unboiled milk has nothing to do with catalase.

[3] Pflüger's Archiv, vol. 67 (1897).

[4] Berichte der Deutschen Chemischen Gesellschaft, Vol. XXIII, p. 675 (1890).

[5] The decrease of the nitrate content during the sweating process of tobacco and the formation of nitrite (and probably of ammonia) thereby may be due to an analogous action of catalase. A short contact, however, does not suffice to accomplish such a change, as a special test showed.

In how many particulars, however, the behavior of platinum black is again encountered in catalase will need to be determined by special investigations. Some authors hold the oxidases to be transferrers of oxygen, but in reality they are transferrers of chemical energy by which certain other compounds are enabled to take up the molecular oxygen directly, which they could otherwise do only at a high temperature. Spitzer ascribes to the iron organically bound in certain nucleo-proteids the property of inducing oxidations. The ordinary oxidase and peroxidase, however, as well as β-catalase, do not possess the general characteristics of nucleo-proteids, but those of albumoses.

The action of oxidizing enzyms in animals has been investigated by a number of authors. It has been found that a pulp made from various animal organs, or extracts prepared therefrom, can oxidize salicylic aldehyde, benzaldehyde, and formaldehyde to their corresponding acids. Methyl alcohol can be oxidized to formic acid, benzyl alcohol to benzoic acid, and the oxidation of acetone and uric acid has also been observed. Various color reactions[1] caused by oxidation, as the formation of indophenol, Bindschedler's green, and totuylene-blue,[2] are also, according to Spitzer, induced by the animal oxidases. Of inorganic materials the oxidation of arsenious to arsenic acid by animal juices was observed by Binz.

It appears that several oxidizing enzyms exist in animals. Pohl prepared extracts which were capable of oxidizing aldehydes but incapable of giving the indophenol reaction. Jacoby observed the destruction of uric acid by dog's liver, but not by calf's liver. We encounter further contradictory statements, especially in regard to the oxidation of glucose and arabinose by the expressed juices of liver and pancreas. Jacoby found the amount of arabinose thus oxidized to be very small.[3] W. Spitzer and others have observed the destruction of a small amount of glucose by blood drawn from animals and by various extracts of animal organs.[4] This so-called glycolysis was ascribed to an oxidizing enzym which, according to Spitzer, gives a blue reaction

[1] These color reactions are best obtained by moistening paper with the reagents and bringing it in contact with the animal pulp.

[2] The colored compounds of Lauth can not, however, be formed by oxidases (Spitzer).

[3] This author further observed that the animal oxidase which easily oxidizes salicylic aldehyde to salicylic acid, is not destroyed at 70° C., and that small quantities of chloroform, or a solution of 0.1 per cent sodium hydrate, stimulate its action, while 1 per cent sodium carbonate, or 0.3 per cent sodium hydrate, prevent it.

[4] Pflüger's Archiv, vol. 60, p. 303 (1895). As examples he mentions that 10 cc. dog's blood can destroy in one hour, at 40° C., 20 milligrams of glucose (determined by titration); 25 cc. defibrinated dog's blood oxidized (completely?) at 39° C., 0.1 gram of glucose in twenty-four hours. The serum is not active; the cellular elements contain the active principle (Lépine, Spitzer). Addition of hydrogen peroxid did not promote the process of destruction, not even upon further addition of palladium, which produced nascent oxygen from the hydrogen peroxid.

with guaiac on addition of hydrogen peroxid, and also shows at the same time catalytic action on hydrogen peroxid. This opinion, however, had already been doubted by Jacoby, who assumes not only one but several oxidizing enzyms in the animal, and also holds that the agency oxidizing the sugar is different from that which oxidizes salicylic aldehyde to salicylic acid.[1]

Quite recently F. Umber[2] has asserted that the destruction of sugar by an extract of the pancreas gland is merely due to microbes, since it is not observed when antiseptic measures are resorted to.

The inability of α- and β-catalase to produce a blue reaction with guaiac solution appears at first sight to be decisive against the assumption that these enzyms can bring on any oxidation; but this inference is not justifiable, since the action of the oxidizing enzyms is sometimes quite specific; that is, they act only on a certain group of bodies of a distinct chemical character or on compounds in which not only a certain degree of lability, but also a configuration, is found that coincides in a certain measure with that of the oxidizing enzym. Grüss has recently observed an oxidizing enzym in barley grains which has no reaction on guaiac, but yields a violet color with tetramethylparaphenylendiamine. He calls it spermase.[3]

The indophenol reaction also can not be produced by catalase. This was tried with a preparation from sweated tobacco and with one obtained by salting out the filtrate of a culture of *Penicillium* by ammonium sulphate. A trace of hydrogen peroxid in the control case sufficed to produce this blue color in the mixture of paraphenylendiamine and α-naphthol in presence of sodium carbonate, even in the absence of oxidizing enzyms.

A characteristic oxidation by catalase, however, is produced with hydroquinone, the odor of quinone being developed within a very short time. This has been tried with β-catalase salted out from the juice of potatoes, with extract of poppy seed, with a concentrated extract of sweated tobacco, and, further, with tobacco that had been well extracted with water containing chloroform. This well-washed tobacco, containing a considerable amount of α-catalase, gave, after being moistened with a dilute solution of hydroquinone and standing fifteen minutes, the characteristic quinone odor, which after

[1] Virchow's Archiv, vol. 157, p. 235 (1899).

[2] Zeitschrift für Klinische Medicin, vol. 39, p. 13 (1900).

[3] Sometimes the reaction of the medium to be tested has to be carefully observed, since certain color reactions, as, for example, the indophenol reaction, succeed only in weak alkaline solution. Sometimes certain compounds may also be present which interfere with the production of the reaction. Thus, Epstein observed that the action of the oxidase contained in fresh juice of beets is prevented by the presence of prussic acid, and is restored when this is expelled by a current of air. This is also a decisive proof of the enzymatic nature of the oxidizing phenomena in fresh beet juice. (Archiv für Hygiene, vol. 36, p. 140.)

twenty-four hours became very strong. The same moist tobacco was heated in a closed vessel to 95° C. for ten minutes and then moistened with the same solution, but no trace of the quinone odor could be perceived, even after twenty-four hours. The same negative behavior was observed with tobacco cured with artificial heat at a higher temperature and therefore containing no catalase (flue-cured bright-yellow Virginia tobacco), no trace of the odor being produced.

The sweated tobacco which was used in the tests with hydroquinone was free from oxidase and peroxidase and did not contain any other known enzym;[1] it therefore follows that α- and β-catalase belong to the class of oxidizing enzyms.

The smell of quinone produced by the action of animal catalase upon hydroquinone is less marked, perhaps on account of the presence of too large a proportion of impurities of a protein nature. But this oxidation can be observed well when to a concentrated extract of beef, made at the ordinary temperature, 1 per cent of hydroquinone is added and the mixture is left for several days in a large flask plugged with cotton. The hydroquinone produces a precipitate and also a gradual and moderate darkening of the mixture. It furthermore prevents, in that concentration, bacterial development. When after several days a little oxalic acid is added, a very marked odor of quinone is developed, becoming much stronger on heating.

While certain oxidases can oxidize very dilute eugenol to vanillin, catalase seems incapable of accomplishing this; at least no odor of vanillin was noticeable after one day. Nor is ethyl alcohol oxidized by it either to aldehyde or to acetic acid, and cyanin is not decolorized by it, although this compound is easily destroyed by other oxidizing agents, as, for example, hydrogen peroxid. Saligenin and indigo carmin are not attacked by it, at least not in neutral solution.

Other tests were made to ascertain whether carbonic acid would be produced from various organic compounds by the action of α-catalase. Sweated tobacco, rich in α-catalase, was well extracted with chloroform water at the ordinary temperature, pressed, and an amount corresponding to from 35 to 40 grams of dry matter put in a flask, after being moistened with solutions of the organic substances to be tested, and heated to from 55° to 60° C. in a current of air, which had passed through a solutionof caustic potash and then through a flask containing chloroform. For absorption of the carbonic acid a solution of barium hydrate containing 0.62 per cent of BaO was used. Each test lasted one hour. Control tests were also made, since not only the absorption of carbonic acid from the air by the tobacco before it was placed in the flask, but

[1] It is scarcely necessary to state that the common hydrolyzing enzyms—diastase, emulsin, papain, etc.—have not the power of oxidizing hydroquinone to quinone. The writer has especially assured himself on this point.

lso the oxidation of certain organic materials contained in the leaves, vas possible.[1]

It was found that of the 25 cc. of baryta water applied in the two ontrol cases there were neutralized 3.1 and 3.4 cc., respectively. The ther results were as follows:

Compound.	Concentration.	Baryta water neutralized.
	Per cent.	*cc.*
Sodium malate	6	3.5
Sodium tartrate	6	5.0
Sodium citrate	6	9.1
Tyrosine	1	4.0
Nicotine sulphate	1	3.5
Soap	10	3.5
Glucose	20	6.2

During the one hour the test lasted no distinct traces of ammonia were produced either from tyrosine or nicotine. These compounds might, however, show less resistance under the influence of other oxidation processes of a considerable activity as, for instance, in the fermenting of the tobacco piles. The amount of carbonic acid produced in this short time was also but small, and may represent a mere by-product of partial oxidations. Some oxidation in the above cases can only be assumed for glucose and citric acid, since the other numbers differ too little from those of the control case.

Another special test showed that an aqueous solution of 0.5 per cent glucose, in presence of 1 per cent phenol as an antiseptic, is not changed by β-catalase at the ordinary temperature within a fortnight. The solution was kept in a large closed flask in contact with much air, and was repeatedly titrated with Fehling's reagent. The result may differ, however, when the mixture is exposed to the air on a porous surface and in presence of an alkaline reaction.

THE PHYSIOLOGICAL IMPORTANCE OF CATALASE.

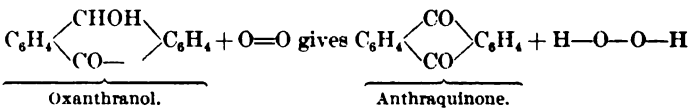
There does not exist a group of organisms or any organ or even a single vegetable or animal cell that does not contain some catalase, as far as the observations of the writer go. This general occurrence of catalase in the organized world can not be accidental and must have a certain significance. Since the destruction of hydrogen peroxid is the most characteristic property of catalase, can this property be of physiological value? Is there any production of hydrogen peroxid in the living cells, and, if so, is the destruction of this product of advantage to the cells? The catalase of the cells would energetically destroy any trace of this compound immediately after its formation (see also

[1] By the previous extraction with water, fatty matter, nucleo-proteids, and a portion of the coloring matter could not, of course, be removed.

p. 17.) The possibility of the production of hydrogen peroxid in the living cells while the energetic oxidation representing the respiration process is going on, can not be denied; it is, in fact, very probable. Recent investigations have shown beyond a doubt that labil hydrogen atoms in an organic compound can form hydrogen peroxid on coming into contact with free oxygen. When it happens that the main organic complex is otherwise not readily oxidized, and especially is not easily changed further by the hydrogen peroxid formed, the amount of the latter produced can be determined quantitatively. Thus it can be shown that this amount corresponds to the amount of the labil hydrogen atoms which have separated from the organic compound to combine with molecular oxygen. Such a compound is phenylhydroxylamine, studied by Eugen Bamberger.[1] It has a relatively stable atomic structure, the two unstable atoms being the two hydrogen atoms in the hydroxylamine group, which are inclined to combine directly with one molecule of oxygen when exposed to the air in aqueous solution.

$$\underbrace{C_6H_5NHOH}_{\text{Phenylhydroxylamine.}} + \underbrace{O{=}O}_{\text{Molecular oxygen.}} \text{ gives } \underbrace{C_6H_5NO}_{\text{Nitrosobenzene.}^2} + \underbrace{H{-}O{-}O{-}H}_{\text{Hydrogen peroxid.}}$$

In presence of sodium hydrate the hydrogen peroxid formed is rapidly consumed again, the nitrosobenzene being thereby oxidized to nitrobenzene. Hence the primary formation of hydrogen peroxid in this latter case escapes notice, which also happens in numerous other instances of autoxidation. Cases exist, however, where even in presence of sodium hydrate the hydrogen peroxid remains unchanged, as shown by W. Manchot.[3] Oxanthranol dissolved in alkalies forms a red solution which in contact with air is rapidly decolorized and separates white anthraquinone, while at the same time hydrogen peroxid is produced.



It was found by that author that for one molecule of anthraquinone one molecule of hydrogen peroxid was produced, which confirms the correctness of this equation. Quite in analogy is the transformation of dihydrophenanthrenquinone to phenanthrenquinone, that of hydrochrysoquinone and hydroretenquinone to their respective ketones, and that of hydrazotriazol to azotriazol.

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[1] Berichte der Deutschen Chemischen Gesellschaft, vol. 33, p. 113 (1900).

[2] The nitrosobenzene thus primarily formed is acted upon by still unchanged molecules of phenylhydroxylamine and forms azoxybenzene. Three grams of phenylhydroxylamine in 40 cc. water yielded, after treatment with a current of air for seventy hours, 2.5 grams azoxybenzene and 0.398 gram hydrogen peroxid, which corresponds to 92.5 per cent of the theoretical yield.

[3] Ueber freiwillige Oxydation, Leipzig, Veit & Co., 1900.

Hence the view of Traube that *nascent* hydrogen atoms can reduce molecular oxygen to hydrogen peroxid can also be extended to *labil* hydrogen atoms.

The transformation of molecular oxygen into hydrogen peroxid is considered as an activifying of oxygen. In analogy with the formation of hydrogen peroxid the peroxids of organic complexes also may be formed in certain processes of autoxidation, as Engler[1] has recently shown for pinen, amylen, hexylen, styrol, cyclopentadiën, and diallylether. Benzaldehyde yields by autoxidation, according to Baeyer,[2] primarily benzoylated hydrogen peroxid, $C_6H_5—CO—O—O—H$, which easily transfers 1 atom of oxygen upon another molecule of benzaldehyde, or upon some other easily oxidizable material, and thereby becomes benzoic acid. This would, however, not yet justify an attempt to extend the analogy also upon the oxidations caused by the living protoplasm, since it would involve a continuous oxidation of the protoplasm itself and lead to an early death of the cells before reconstruction of the injured parts would become possible. Nevertheless the proteids composing the living matter betray an aldehyde nature by the toxicological behavior of the living matter.[3]

The oxidations in the living protoplasm have often been ascribed to an activified oxygen, and doubtless many chemists would feel inclined to assume the formation of hydrogen peroxid in order to account for oxidations of which common oxygen seems incapable. But it must be considered that the great lability of the proteids of the living protoplasm—in other words, the accumulation of kinetic chemical energy in them—is here a more important factor than the natural tendency of common oxygen or hydrogen peroxid to cause oxidation. It is further a fact that hydrogen peroxid can not be utilized by the living protoplasm as an oxidizer, since the active atomic groups in the proteids of the living matter would be oxidized by it instead of the thermogens stored up in the cells for combustion, and injury or death would result; indeed the highly poisonous character of hydrogen peroxid is well known.[4] Therefore, since the oxidation in the respiration process would take a detrimental turn if hydrogen peroxid accumulated as a by-product, the rôle of the catalase may possibly be explained. It would destroy every trace of this poisonous substance as quickly as it were formed and would thus afford an important protection. The

[1] Berichte der Deutschen Chemischen Gesellschaft, vol. 33, p. 1103.

[2] Ibid., p. 1582.

[3] These points are fully discussed in chapter 12 of the treatise of the writer, Die chemische Energie der lebenden Zellen, Munich, 1899, E. Wolff, publisher.

[4] In a dilution of 1: 200 hydrogen peroxid kills cholera bacilli in three minutes; of 1:15,000 it impedes development of typhoid bacilli; of 1:10,000 it kills infusoria in from fifteen to thirty-six minutes; and in one of 1:1,000 algæ are killed in a short time. Intravenous injections kill mammals by stopping respiration.

oxygen set free by this destructive operation could at once be utilized again for the continuance of the respiration process.[1]

It may be asked what function the catalase performs in fermenting yeast and anaërobic microbes, since in these there is no normal respiration process and hence no occasion for the formation of hydrogen peroxid by autoxidation.[2] Catalase must then have still another function, and the writer is inclined to assume for it the faculty also of loosening chemical affinities in certain compounds to such a degree that the protoplasm itself can more easily split them, or, when oxygen has access, can more easily oxidize them. In other words, catalase might represent an aid for fermentative as well as as for respirative phenomena. In the case of the yeast it may be of importance for the action of Buchner's zymase. The amount of catalase in yeast is relatively large (see p. 35), and the expressed juice of yeast is also rich in it. Catalase may also be capable of accomplishing certain reducing processes, since platinum black can also induce reductions as well as oxidations (see above, p. 37). An enzym with a reducing action was recently observed by Abelous and Gérard in the aqueous extract of the horse kidney. It is capable of reducing nitrates to nitrites, and nitrobenzene to aniline.[3]

Since catalase is of universal occurrence in the organized world, and is capable of destroying every trace of hydrogen peroxid as soon as it is formed, it is quite impossible that the latter product could ever be found in living cells. The assertions, therefore, of Clermont, Wurster, Bach, and E. Baumann to the contrary have lost every trace of justification. Direct tests by Bokorny, Pfeffer, Cho, and others, have proved the incorrectness of this assumption.[4] It is evident, further, that Reinke's hypothesis of the respiration process,[5] which assumes the formation of hydrogen peroxid as a necessary intermediate step to enable the combustions to take place in the protoplasm, must be abandoned. The protoplasm would hardly prepare a special enzym

[1] Some authors go so far as to ascribe the entire respiration process to the activity of certain enzyms. This view is certainly incorrect; otherwise the oxidations characteristic of the respiration process should continue qualitatively and quantitatively, after heating cells to their death point (40°–50°C).

[2] Among the obligate anaërobic microbes the bacillus of blackleg was tested and also found to contain catalase.

[3] Académie des Sciences, meeting of December 11, 1899.

[4] It may also be mentioned that Schoenbein's assertion of the occurrence of hydrogen peroxid in the violet fluorspar of Wölsendorf has been refuted, since the writer demonstrated long ago that Schoenbein's results are not due to the presence of that supposed "antozon," or to hydrogen peroxid, but to traces of free fluorin, probably formed by the gradual dissociation of small quantities of a superfluorid of cerium. The sentence on p. 113, Vol. XIII, of the "Handwörterbuch" relating to Schoenbein's observations should therefore be corrected.

[5] Botanische Zeitung, 1883, Nos. 5 and 6.

iat would destroy with great vigor and promptness a product necesiry for its respiration.

The protoplasm represents a most complicated machine, built up f easily changeable proteids. This easy change to comparatively table forms, in the process of dying, implies a loss of the labil atomic roups by atomic migration in the molecules, and a loss of kinetic hemical energy.[1] The atoms of the labil groups are in continuous iotion, representing a charge with kinetic chemical energy. This nergy is transferred by the protoplasm to the thermogens, princiially sugar and fat (lecithin), which at the ordinary temperature are iot at all disposed to oxidize themselves directly on contact with air. 3y contact with the living protoplasm, however, they become capable of thus oxidizing themselves, since the protoplasm imparts to their itoms such a state of motion that their affinities are loosened and they an take up oxygen from the air without the oxygen being previously ictivified. This splitting of the oxygen molecules and the combining of the oxygen atoms with the atoms in sugar and fat proceeds at one and the same moment; but at the same time certain labilized activified hydrogen atoms of the thermogens can combine with still entire molecules of oxygen, thus forming hydrogen peroxid as a by-product, as previously mentioned.

The heat produced by the combustion of the thermogens is again turned in a certain measure by the living protoplasm into chemical energy, since the heat energy instigates the atoms of the labil groups to much more intense oscillations than is the case with the more stable atoms. The easy transformation of heat energy into chemical energy is known. The former represents motions of molecules and atoms, the latter an atomic motion which consists of oscillations of a greater amplitude than the motions induced by heat energy. This can be inferred from the fact that, other things being equal, chemical energy is capable of loosening affinities in molecules much more readily than heat energy can at a moderate temperature.

When the thermogens are consumed in the cell without a fresh supply being available, the labil proteids of the living protoplasm themselves take up oxygen. Thus by their partial oxidation a disturbance is produced which may, at a certain stage, lead to the total collapse of the protoplasm with a loss of all the labil groups. This is the death of the cells by starvation.

When, however, thermogens are present but the oxygen is withheld, the activified molecules of sugar undergo other changes, brought on by the far-reaching loosening of affinities, and lactic acid, alcohol, or fat result, accompanied by a simultaneous production of

[1] This energy is perceptible as heat in the dying of the muscular tissues of animals—the so-called postmortem rise of temperature.

carbonic acid from destroyed sugar molecules. This process, which in most cases is of but short duration and is terminated by the early death of the cells by suffocation, is known under the name of "intramolecular respiration." The recent important observations of Eugen Bamberger furnish an interesting chemical analogy to ordinary and intramolecular respiration. He found that β-phenylhydroxylamine not only oxidizes itself readily on contact with air and induces oxidation of other compounds, as indigo-carmine, but can also, in the presence of a little alkali and the absence of air, change itself to aniline and nitrosobenzene, which represents on the one side a reduction and on the other an oxidation, in full analogy to the changes in intramolecular respiration.

The development of oxygen by the action of catalase upon hydrogen peroxid recalls another instance of development of oxygen; it is the assimilation of carbon. Here the oxygen developed is generally assumed to be derived directly from carbonic acid, as expressed by the following equation:

$$\underbrace{O=C\begin{matrix}OH\\OH\end{matrix}}_{\text{Carbonic acid.}} \text{ becomes } \underbrace{O=C\begin{matrix}H\\H\end{matrix}}_{\text{Formic aldehyde.}} + \underbrace{O_2}_{\text{Molecular oxygen.}}$$

An ingenious hypothesis of Erlenmeyer[1] tries, however, to explain this separation of oxygen by a previous formation of hydrogen peroxid and assumes formic acid to be the first organic product of the assimilation process.

$$O=C\begin{matrix}OH\\OH\end{matrix} + \begin{matrix}H\\OH\end{matrix} \text{ becomes } \underbrace{O=C\begin{matrix}OH\\H\end{matrix}}_{\text{Formic acid.}} + \underbrace{HO-OH}_{\text{Hydrogen peroxid.}}$$

$$\begin{matrix}HO—OH\\HO—OH\end{matrix} = 2H_2O + O_2$$

Since the formation of formic acid is not very probable, we might substitute the following equation which would express an eventually direct formation of formic aldehyde, which by condensation may yield sugar.

$$O=C\begin{matrix}OH\\OH\end{matrix} + \begin{matrix}HOH\\HOH\end{matrix} \text{ becomes } O=C\begin{matrix}H\\H\end{matrix} + \begin{matrix}H_2O_2\\H_2O_2\end{matrix}$$

$$2H_2O_2 = 2H_2O + O_2.$$

Pfeffer[2] gives the following declaration against the above hypothesis: "Erlenmeyer supposed that formic acid and hydrogen peroxid are formed during the assimilation of carbon dioxid—a theory which the absence of hydrogen peroxid from assimilating plants conclusively negatives." The undeniable fact that all reagents fail to show the

[1] Berichte der Deutschen Chemischen Gesellschaft, 1877, p. 634.

[2] Physiology of Plants, Vol. I, p. 356 (1900.)

presence of hydrogen peroxid in the cells can not, however, be accepted by a critical mind as a proof that it is not formed at all, since it would have only an ephemeral existence. By its rapid decomposition it would give rise to the oxygen developed by the chlorophyll bodies—a view which would find some support if it could be shown that the chlorophyll bodies are very rich in catalase.

While Pfeffer's objection can not be considered a serious one, some better-founded chemical objections might be raised. It is a fact that chemistry does not show a single instance where two hydroxyl groups can unite to form hydrogen peroxid. Such a process would be improbable, although not impossible.[1]

[1] Brühl (Ber. d. Deutschen Chem. Ges., vol. 33, p. 1710) maintains that hydrogen peroxid can not be a simple "bihydroxyl" HO—OH, but that the formula HO = OH would correspond better with its behavior, since it is free of electric absorption and shows a very high dielectric constant.

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PROGRESS

OF THE

BEET-SUGAR INDUSTRY

IN THE

UNITED STATES

IN

1900.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1901.

U. S. DEPARTMENT OF AGRICULTURE.

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PROGRESS OF THE BEET-SUGAR INDUSTRY IN THE UNITED STATES IN 1900.

REPORT OF SPECIAL AGENT

CHARLES F. SAYLOR.

LETTER OF SUBMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
OFFICE OF THE SPECIAL AGENT,
Washington, D. C., April 15, 1901.

SIR: I submit herewith, for your inspection and approval, my report for 1900 as special agent for the investigation of the sugar industry. It includes the results of my own observations and investigations, and a considerable mass of information pertinent to the subject collected from various reliable sources.

CHAS. F. SAYLOR, *Special Agent.*

Hon. JAMES WILSON,
Secretary of Agriculture.

INTRODUCTION.

This report follows the same general lines as its predecessors. It is prepared in what is believed to be the best form for the general reading public. Technical matter and scientific style are avoided as far as possible. Due attention has been paid to criticisms and comments of the press on previous reports; also to criticisms and suggestions received through correspondence and otherwise.

The instruction of all classes who are or may become interested in the beet-sugar industry has been the object kept always in view. As the interest in this industry is rapidly spreading, and thousands of persons will read this report who never saw those of previous years, it has seemed absolutely necessary to devote some attention to topics already treated somewhat fully in my previous reports. Hence no apology is deemed necessary for repetition.

Those most interested in the success of this industry in the United States are certainly to be congratulated on the rapid and substantial

progress it has made. Only a few years ago our people were entirely unacquainted with any phase of the sugar industry except the consumption of the product. Capitalists knew nothing of its manufacture except that large capital was necessary to start the industry. The farmers had to be educated in a new branch of agricultural production. The capitalists had to learn all the conditions necessary to the success of a factory. The broad domain of the United States had to be investigated and the conditions of localities tested. Along these lines a vast amount of preliminary work has been done. The beet sugar belt has been successfully delimited, and in many localities within that belt the industry has successfully passed beyond the experimental stage.

Primary work was necessarily the first requirement. The Department of Agriculture, working in conjunction with the State experiment stations, has been diligently experimenting and solving the agricultural questions that entered into the beet-sugar problem. The kinds of soil, the conditions of climate, the sections of country, the cost and profits of production, the direct and indirect benefits to the farming industry are subjects that have been carefully studied, and the results have been published. The secular and agricultural press, and writers and lecturers on agricultural subjects have all aided materially in this work.

Capitalists have investigated the statistics of those countries of Europe that have had this industry established for some time. They are becoming much better posted on the questions involved, such as the amount of capital required, the profits of manufacture, and the conditions necessary in establishing a factory at any given point. This primary education is now a part of the general information of the country.

There has been a marked tendency during the past year toward a crystallization of ideas into something tangible and peculiar to our own conditions, so that a less effort will be followed by a greater accomplishment than formerly, and the effort itself has been greatly stimulated. We can expect, as the years roll on, to see this industry safely established and making sure progress.

While the record of conditions that obtain in farming localities is being made up, the farmers themselves are gaining information as to the culture and uses of the sugar beet and its cost of production. They are learning the value of the crop for stock-feeding purposes. No well-regulated farm should be without facilities for storing up a good supply of these roots for feeding purposes. They are a valuable element in the food ration of the dairy cow or the fattening lamb or steer. They are excellent for brood animals. They can be easily prepared as cooked food. In any manner fed they are easily digestible. They are very desirable as a food ration in which the cereals enter to

a considerable extent. They seem to mitigate the evil effects of feeding hogs on an exclusively corn ration. All these facts are coming home to the farmers. It can readily be observed that, at this stage of the industry, efforts put forth by the Department of Agriculture, the State experiment stations, and others who are competent to give information are very much more effective.

The public mind is much better prepared to receive facts and literature bearing on this industry than it was three or four years ago. Outside of the actual accomplishment in the way of establishing factories and developing information incident to sugar-beet growing in this country the receptive mood of the people would in itself repay the cost of the effort that has been put forth. Public interest manifests itself in many ways. One scarcely meets a farmer or business man these days who has not given more or less attention to the results of sugar-beet experiments that have been carried on, and they generally express faith in the success of beet-sugar enterprises.

While capitalists as well as farmers manifest a deep interest in the future of the sugar industry, they have been no doubt somewhat restrained by the uncertainty attending the future of our new island dependencies, which are themselves largely sugar producers. On this subject little need be said. The writer speaks not only as the result of careful consideration of all the available data on the sugar industry in these dependencies, but as the result of personal visits to Hawaii and Porto Rico, and has no hesitation in asserting that were the opportunities for developing this industry in these new territories to be extended to their utmost capacity there would be nothing in this to discourage our domestic sugar producers. For years our domestic sugar consumption has been increasing even more rapidly than the increase of population, until during the past fiscal year our imports of sugar attained the enormous total of nearly 2,000,000 tons. For generations to come, then, it will be necessary for the people of the United States to import considerable sugar over and above what we are likely to produce, and of this importation the combined production of our new island dependencies will not do more than supply a part, and let us hope a large part.

Seed Distribution.

The distribution of seeds from both the Department of Agriculture and the State experiment stations has become more systematic. The Department has usually followed the rule of sending out seeds in bulk to some individual or center, where the parceling out to individuals has been accomplished in a systematic manner. The State experiment stations followed a system of making up their own lists of farmers for distribution of seeds. These names were selected from those known to be successful and attentive to farming interests.

During the past year the system of seed distribution has been improved and made more effective. Most of the State experiment stations have been stimulating local organizations, known as "Sugar-beet growers' associations." An association of this kind represents a certain limited district or territory. A sufficient number of plats of ground are laid out to test the various soils of that section. The farmers owning these plats are furnished the beet seed and given special instruction on sugar-beet culture. In some cases the farmers give the use of the plats of ground and the association hires a competent superintendent and employs the laborers needed in the growing of the beets on these plats. This method is very desirable, but its success depends upon the ability of the association to collect funds for defraying the expenses. This method makes the data concerning the planting, cultivation, harvesting, and disposal of the beet crop easily obtainable and at the same time accurate. Thus the methods of investigating this industry are becoming more definite and systematic. The facts are compiled and published and become a part of the history of the beet-sugar industry. Almost every farming section in the United States where the success of sugar-beet culture seems at all probable has been investigated, tested by actual experiments, and the results have been put on record.

Consumption of Sugar.

The consumption of sugar in this country is increasing very fast. The development of the arts and manufactures constantly calls for an increased amount of sugar. Outside of the demand which comes from the use of sugar as an article of diet, this increase in consumption is growing with our industries.

The use of sugar, except for apothecary purposes, is quite modern when we consider the generations of the human family. Queen Elizabeth was one of the first practical patrons of sugar. She ordered it regularly on her table, both as an article of diet and for the purpose of calling the attention of her people to its utility. In the comparatively short time which has since elapsed, what appeared as a royal caprice has become an established custom of the people in all civilized nations. Hardly any other article of food deserves more than sugar to be recognized as a staple item of diet. It is comparatively recent when Napoleon asked his scientists to name a source and a process through which France would be able to furnish her own supply of sugar when she was blockaded by hostile armies. In that short time has been evolved the processes, the immense output of products, the capitalization, and the vast employment of labor that has given the sugar beet the place in the world's economy which it occupies to-day.

In this country there is scarcely an individual who can not be classed a consumer, regularly and directly, of this product. It is only nec-

essary to study the constantly widening use to which sugar is put in order to understand the wonderful increase in its consumption. Even as an article of diet the amount of sugar consumed per capita has grown greatly in the last half century and quite perceptibly in the last quarter. The prime reasons for this increase are (1) the fact that the people are becoming more able to purchase the good things of life; (2) the gradual cheapening of sugar. Many things that were formerly luxuries are now real necessities. In the homes of the people sugar was first on the list to be affected by the demand for a better style of living. As the years roll on this increase will be more or less constant.

New theories and discoveries are constantly increasing the consumption of sugar. The United States War Department is shipping over 37,000 pounds of candy monthly for the use of the soldiers in the Philippines, who are thus encouraged to purchase it on the theory that a certain amount of saccharine matter is desirable as a supplement to the regular ration. Similar experiments have been tried on the different armies in Europe, the results of which have been favorably reported. Many physicians and scientists indorse the use of sugar as a regular part of army rations.

There has been a great increase in the use of sugar in the manufacture of druggists' supplies, in the formation of tinctures and sirups of all kinds. In the confectioners' art we find an industry that has grown beyond all comparison in all sections of the United States, and with the growth of this industry has grown the demand for the raw products, chief among which is sugar.

The industry, however, that has entered most into the demand for sugar and has been most constant in its growth is that of preserving fruits. The preserving industries are among the most important in several of the States. As new facilities are acquired for opening up and bringing into use new agricultural lands—such, for instance, as irrigation—new fruit industries are constantly being established, the products of which must find a market. For the preparation of the fruits for market canneries have been established, and in this way preserved products—such as jellies, preserves, jams, and the like—are constantly being pushed out into the trade. Sugar is an important factor in the prepartion of these articles for market.

Other industries might be mentioned, but enough has been said. It is only necessary to add in this connection that most of these industries which consume sugar largely are young; they are constantly growing and widening in their sphere. Taking into consideration the growth of these industries and the tendency of our people, as shown by the past, the demand for sugar in the future in this country is sure to be progressive and extensive.

Business men, farmers, and capitalists need not apprehend that our insular possessions will, under any conceivable condition of things, be

able to supply this country with an excessive amount of sugar. With our present demand and the growth of our consumption it will not be possible for our home producers and those of the islands to furnish all the sugar we shall need. It must be borne in mind that the available maximum production of these islands is practically known, as well as the limits which they can not exceed. For the remainder we will be compelled to buy sugars that come into our market from abroad.

The following statistics are compiled from an article in the Weekly Statistical Sugar Trade Journal, published by Willett & Gray. These statistics offer some very valuable information on the amount of sugar consumed in this country and the growth of consumption:

Tons[a] of sugar consumed in the United States in 1898, 1899, and 1900.

Classification.	1898.	1899.	1900.
Net imports of foreign sugar	1,638,937	1,839,642	1,960,014
Domestic cane sugar	252,812	160,400	174,450
Domestic beet sugar	34,458	62,826	82,736
Maple sugar	5,000	5,000	5,000
Sugar made in United States from foreign molasses	1,700	5,200	7,647

[a] Tons of 2,240 pounds.

Consumption of sugar in the United States, 1881 to 1900.

Year.	Total amount of sugar consumed.	Increase (+) or decrease (−).[a]	Consumption per capita.
	Tons.[b]	*Per cent.*	*Pounds.*
1881	998,532		
1882	1,061,220	+ 6.80	
1883	1,170,375	+10.30	
1884	1,252,366	+ 7.00	51.00
1885	1,254,116	+ 0.14	49.95
1886	1,355,809	+ 8.11	52.55
1887	1,392,909	+ 2.73	53.11
1888	1,457,264	+ 4.62	54.23
1889	1,439,701	− 1.21	52.64
1890	1,522,731	+ 5.80	54.56
1891	1,872,400	+22.96	67.46
1892	1,853,370	− 1.10	63.76
1893	1,905,862	+ 2.83	63.83
1894	2,012,714	+ 5.08	66.64
1895	1,949,744	− 3.27	64.23
1896	1,940,086	− 0.53	60.09
1897	2,070,978	+ 6.79	63.50
1898	2,002,902	− 3.29	60.30
1899	2,078,068	+ 3.75	61.00
1900	2,219,847	+ 6.82	66.60

[a] As compared with the previous year. [b] Tons of 2,240 pounds.

Forces which are Educating the People in Regard to the Beet-Sugar Industry.

In this report I have thought best to briefly review the various forces which are at work educating the people of all classes in America regarding the benefits, the methods, the art and science of the beet-sugar industry.

SYSTEMATIC PROPAGANDA.

In keeping with the public interest that has been aroused regarding this industry, are the systematic methods of propagating ideas touching the industry. Public meetings have been held in many localities during the past year. Meetings of this kind are attended by the business men and farmers of the respective localities. Speakers well qualified to present the various phases of the subject address these meetings. The methods of planting, cultivating, and harvesting sugar beets are discussed; also the conditions and requirements necessary to the establishment of a sugar factory, along with the cost of instituting the same.

The benefits of locating such an industry in that particular locality are outlined. This is the first step to arouse public sentiment. It is made pretty clear that the establishment of no other single industry could touch so intimately all phases of life as would that of the sugar industry. It is shown that it would give an impetus to several other industries, such as stock feeding and dairying. It is also shown that the production of sugar beets and the manufacture of the same into sugar involves an expenditure of a large amount of capital; that the demand for labor is greatly increased, so that no one desiring employment need go without it; that it increases the population of a district and stimulates business through all of its channels, and that a condition of prosperity prevails wherever this enterprise is instituted.

Other meetings follow, out of which crystallizes an effort to thoroughly and systematically test the conditions of the neighborhood for growing sugar beets. If results are sufficiently favorable, an effort is made to enlist the attention of capital to the extent of establishing a beet-sugar factory. These meetings give the press something tangible to present to the reading public, and before long farmers, business men, and capitalists are all more or less convinced of the mutual benefits that might be derived from building a sugar factory.

These meetings and the good work of the press usually result in the holding of a convention representing a large area or district. Experts and experienced beet-sugar advocates are called in, and the claims of this industry are presented in a methodical and systematic manner. Capital is usually represented. The final result is that a company is organized and the factory started. Future investigations simply become a matter of future experience in the practical operations of a concern.

FACTORIES AS EDUCATORS.

The education of the people on this subject has been aided by the building of sugar factories. A few years ago the existing factories were confined to a few localities. Persons desiring to gain practical information concerning the operation of a sugar factory or the raising of the beets therefor usually had to make long and expensive trips to

visit such factories. With the building of new factories the facilities for gaining such information have greatly improved.

The information gained by the farmer who is seeking light on the practical side of sugar-beet growing makes a much deeper impression on his mind when he is able to go into the beet fields near a factory, examine the soils, and talk to the farmers who produce the beets. Here he learns the soil and moisture requirements of beets; the methods of their cultivation; the average tonnage per acre and the market price; the cost of production and the profit or loss involved; the factory requirements regarding the beets; and many other important facts.

Capitalists and business men have the same open field for investigating their side of the proposition. Business men discover the benefits to all kinds of enterprises. In expending the money to build a factory large amounts of materials are used and labor is demanded. Most of the returns in money secured by the factory for sugar manufactured is spent in the locality or district for crude materials or some form of service. This is true with all of the receipts, in fact, except the profits of the concern, and these profits stay to enhance the values of the district if the concern is capitalized by actual residents. Capitalists, after a short investigation, are enabled to formulate correct ideas as to the cost of building a factory and the profits to be secured from its operation.

There can be no question as to the material value of this source of education. The owners of the earlier factories are to be commended for their liberality in devoting time and effort to the instruction of visiting committees who were seeking such information. I have never heard of a bona fide investigating committee of this kind to whom the factories did not give every opportunity to gather the desired facts.

The factories are not only interested in improving the conditions and facilities for making sugar, but they are also interested in bettering the methods of agriculture by which sugar beets are grown. Every well-regulated factory has what it terms an agriculturist. It is his business to supervise the growing of all the beets for the factory, and to secure the contracts from the farmers for the same. The factory must know that it is to have sufficient beets to carry it through the campaign and that these beets are of suitable quality. On this matter everything depends.

In the contracts with the farmers are the rules and regulations governing the treatment in growing the beets. The agriculturist makes a careful study of the best soils accessible to the factory and makes his contracts accordingly. He inspects and directs the growing of all the beets during the season, and issues notice to the farmers when to deliver their beets. The intimate relation which the factory sustains to the farmer, as a producer of its raw material, is one of the beneficial

things on the agricultural side of the question. The agriculturist is selected on account of his peculiar fitness and proficiency. He is a student of agriculture and an observer of its conditions. He is a great help to the agricultural community.

EXPERIENCE AS AN EDUCATOR.

In harmony with the confused state of the public mind in the beginning, is the lack of method and unorganized effort on the part of the management of new factories. In most instances the attempt has been made to organize a company, build a factory, and put it into operation within a year. There would be considerable hazard in this haste even if the projectors and everybody concerned, including the beet growers, had had experience and thoroughly understood their business. The bad effects of this hurry-up method become all the more apparent when it is understood that most of these companies are organized and the factories are built by men who know absolutely nothing about sugar making. They are located in farming districts where farmers know nothing about growing sugar beets except what they may have read or heard. They are absolutely without practical experience. And yet they are called upon to produce a crop of beets while the factory is building.

The difficulties in building a sugar factory are so many and call for such constant attention from those interested that they find their time thoroughly occupied. They have no time to give to the growing of the crop of sugar beets upon which everything depends for the success of the factory during the campaign. I have known those interested in building a factory to be so occupied with its construction that they were never able to get out and observe any of the fields of beets during the growing season. They did not know whether all the requirements had been complied with or whether none of them had. One of the managers said to me: "I have all I can do to build a factory; it is the farmers' business to grow the beets." There was no one delegated from this particular factory to make any observations of the crop or offer any help or instructions to the farmers. The results taught the managers of this factory, before they had finished the first campaign, that everything depended on keeping in close touch with the farmers. This was an extreme case, of course, but it must be apparent that, with the amount of work and worry required to build a factory in so short a space of time, very little time or interest can be devoted to the crop out of which the sugar must be made.

Factories usually have, and always should have, an agriculturist with a competent corps of assistants, through which the most necessary aid and instruction can be offered to the farmers constantly. As a rule these new factories start in depending largely on their skilled employees for information on all the lines from the time the seed is planted to

the time the sugar is placed on the market. This is necessarily the case. Men who have been interested in other lines of business have put their money into the concern. The farmers have been growing other crops whose culture is entirely unlike that of sugar beets. For a while the principal thing gained by those connected with such a factory as this is experience. This is one of the most necessary features in the development of the industry in this country. Unfortunately it is something that requires time, but as the work goes on each individual worker becomes more experienced; each learns to depend more on his own resources, and learns to shorten and lighten the labor which falls to him; he learns better methods, originates better processes, and becomes an artisan in so far as the scope of his talents and opportunities permits.

The man who has ventured his money in the enterprise, and who is the real power behind it, gradually gathers the information necessary to enable him to operate a sugar factory. He learns to examine and improve the machinery and the processes when it is necessary, and he learns when it is necessary; he becomes a student of the operation of the concern as a whole; he knows where to economize, and where to invest for the purpose of economy.

The farmer goes through the same course of practical education. Every year he is able to produce beets cheaper and better; he is enabled through experience to take advantage of all of the benefits incident to his participating in this industry; he will finally acquire the ability to produce the most beets and the best beets for the least money. His first experience is liable to be discouraging. His tonnage is low, the quality of his beets is poor; he discovers the causes, and aims at improvement in his next effort. He finally becomes master of the situation, finally discovers there is a vast difference between trying and knowing. He finds he has worked out his side of the task; he feels competent and confident; he knows that it is a profitable field crop. This difference between the results of an inexperienced farmer and a successful one through experience is the coefficient through which we determine the grand total of success by using as a factor the total number of farmers engaged.

At the Paris Exposition statistics were offered in the German department to show that Germany had been enabled to decrease her cost of production of sugar, during a certain definite time, 25 per cent.

In my last report I included the statistics of Germany for twenty-two years to show how she had gradually grown up in her tonnage per acre, in the sugar content and purity of the beet, and in the amount of sugar produced per acre. At the same time the cost of production had been gradually decreased. These are all important items redounding to the benefit of the farmer through experience.

When those in this country who are interested in this industry shall

have attained the proficiency which can come only through experience, then, and then only, will the industry be established under its best conditions. This must be borne in mind in making our estimate of the eventual cost of producing sugar here. When comparing our home industry with that of any other country, we must consider that there is a large amount of slack here that must be taken up. Another feature that we are entitled to consider is that the American, as a rule, has largely excelled artisans of other countries in his quicker and better methods, in his ability to cheapen processes and to make up to a large extent for the item of cheaper labor in other countries by his superior artisan ability. This has been demonstrated, and is being demonstrated every day in the manufacture of sugar. The tact, ingenuity, artisan ability, and hustling qualities of the American may be counted as an asset in favor of a better and cheaper production of sugar. These, along with the benefits to be acquired from experience, are features that are constant, and are bound to affect the future of sugar manufacturing in this country. Until such a time as we can thoroughly comprehend and calculate the effect of these factors we can not be able to give an accurate estimate of the cost of home production of sugar.

THE EDUCATION OF LABOR.

The question of high-priced labor, that must necessarily enter into all our estimates of cost of production, necessitates a constant vigilance in the point of quickening and cheapening the processes of manufacture. The very item which always appears to our disfavor in comparison with other countries offers the stimulus for closer investigation and for final favorable effect. Through experience we are educating our workmen, lessening the work, removing the obstacles, and meeting the problems which constantly occur. Each campaign brings forth better, easier, and cheaper methods. Each new campaign is entered upon with a new zeal for investigation and improvement.

It is interesting to note the limited amount of skilled labor with which new sugar factories begin their work. In the beginning considerable of this labor had to be brought over from Europe. There are certain places in a sugar factory that can only be filled by workmen skilled in a particular feature of the work.

When the fires are built and the machinery is started in motion, the education in sugar making of a large number of persons begins. This is the school out of which are to rise competent workmen who are to fill places of responsibility requiring previous training. Day after day the unskilled workmen follow through the details of their special work in sugar making, under the supervision of the skilled workmen in charge, until they finally become adepts. Each worker, from the one who shovels the beets into the irrigating channel for conveyance

to the factory to the one who watches the temperatures and consistency in the evaporators and boilers, daily becomes more expert in his particular part. He performs the operation with greater ease and greater success day by day. His education and his expertness are a part of the means of bettering and cheapening the factory operations. The company gradually increases the capacity of its factory, remodels its equipment, and cheapens the cost of production, until finally it reaches its maximum of efficiency in sugar production.

As the industry grows and other new factories are built, a demand is created for the services of the graduates from earlier factories. The new factory must secure a quota of men to fill positions of responsibility and requiring skill. This is the opportunity for the promotion of the workmen. Others are put into training for the places of those who go out. The drain is not permitted to impair the operations of the factory. Young men are carefully selected in the beginning and carefully trained. Under our system of popular education, the supply of raw material from which to select these workmen is peculiarly good as well as large.

In this country the young man is not bound by any decree of fate or custom to follow any particular occupation because his ancestors followed it. Here no one is required to inherit an occupation, but every one may select the occupation best suited to his inherited or acquired tastes and abilities. To this fact may be attributed much of the success attained by the American workmen. The factory owners are able to make their selections from young men who see in this industry a calling which meets their peculiar fitness, tastes, and ambition. They see in it an opportunity for promotion; they work in it inspired with the ambition of being future managers or superintendents. In this country such a thing is not only possible but quite probable. Our colleges of agricultural and mechanic arts are turning out a large supply of young men educated scientifically and practically. These institutions, with their thoroughly equipped laboratories, are furnishing abundant material for the needs of the beet-sugar factories.

American-Made Machinery and Implements.

Along with the progress that is being made in the manufacture of sugar from beets in America, and quite consistent with American character, is to be noticed the alertness of our machinery and implement men. From the beginning the manufacturers of factory machinery gave the beet-sugar factory careful study. A large percentage of the factories that have been built have been designed and the equipment has been planned by American architects and designers. A good percentage of the machinery in the factories is home manufactured. There is probably not a factory in this country that does not possess more or less of the American-made and American-designed machinery. Many of them are so equipped throughout.

Where most of the trouble has arisen on trial with new machinery the same has turned out to be foreign made; and it is a further very noticeable incident in this connection that where the machinery has been displaced in a sugar factory for the purpose of obtaining better results it has been largely at the expense of the foreign-made machinery by introducing something of the American pattern. Instances could be pointed out where factories were built no later than last year equipped with the latest foreign-made machinery, which was later torn out and replaced by American-made machinery at an expenditure reaching from $50,000 to $100,000.

We can confidently look to the future career of the American manufacturer for the new era in beet-sugar machinery. The same may be said in reference to agricultural implements for seeding, cultivating, and harvesting the beet crop. From the beginning the manufacturers of farming implements gave this subject careful attention and study. Experts were sent into the fields and implements were designed and put into use to meet the peculiar features of agriculture in the various sections. Results were carefully watched, implements were improved to meet obstacles encountered. The noticeable feature that appears in comparison with foreign-made machinery is that the American article is not nearly so cumbersome. It aims to accomplish the same results without so much laborious effort by man and horse. It is probable that the expense to the manufacturer of implements has been more than the profits he has derived. With true American enterprise he has anticipated the fact that this industry is to be established on a sure and extensive basis. His reward will come in the demand for this class of agricultural implements which is bound to come in the near future.

Constant progress has marked the history of this industry. In no other field of mechanics and agriculture have improvements been so pronounced. Its introduction into the United States is the beginning of a new era of discoveries and improvements. I will suggest some of the problems that are to be worked out in its inauguration here:

It is patent to everyone that the seeding and harvesting implements hitherto used have not been well adapted to saving time, labor, and expense in doing the work for which they were designed. For instance, 20 pounds of seed per acre are required in order to insure a crop. These seeds are sown continuously from one-half to an inch apart in a row. After the plants are up and when they possess three or four leaves most of them are cut out, leaving the remainder in bunches from 8 to 12 inches apart. If some successful plan could be arranged for planting them in bunches in the beginning it would do away with the labor of bunching and save at least two-thirds of the seed. This would save at least $1.65 per acre for seed alone, in addition to the cost of bunching, which would probably be much more.

Specially designed seeders have been offered to accomplish these results.

The implements for harvesting that have been in use hitherto simply loosen the beets, leaving the rest of the labor to be performed by hand. The beets must be topped by a laborer picking them up one at a time and giving a stroke of the knife to remove that part of the crown above the sun line along with the leaves. The beets are then usually thrown in piles and afterwards thrown into sacks, which are conveyed in wagons to the railroad car or factory.

Harvesting implements have been designed not only to loosen the beets, but to remove the tops, shake off the dirt, and to throw the beets into wagons as the machine proceeds. I am unable at this time to give a definite statement as to whether or not these machines are effective in doing the work properly and in lessening the cost of labor. Neither am I able to state at this time whether or not the planter described above is a success; but I believe that experience and trial will eventually lead to the saving of time and expense along the lines indicated.

Superintendents and managers of factories are giving special study to the details in the process of manufacturing sugar with a view to eliminating cumbersome methods and introducing effective ones. The operation of each piece of machinery is given attention, and new designs are introduced when it is thought the processes can be bettered. There is scarcely a manufacturing company that is not working out some peculiar feature of machinery or operation which has been suggested by experience. Some of these new features are made known; others are kept secret.

Bounties and Other Methods of Promoting the Industry.

Under this head attention is first called to the action of legislatures and courts in various States regarding State bounties. Promotion by bonuses and exemption from taxation by municipalities are then briefly discussed.

BOUNTY LEGISLATION.

Since my last report some of the State courts have taken definite action touching the bounty system. This is a method of encouragement devised for the purpose of stimulating the introduction of the sugar industry and attracting the attention of capitalists.

The States that have already paid bounties for the manufacture of sugar are New York, Michigan, and Minnesota.

The legislature of Illinois passed the bounty law offering 1 cent a pound on all high-grade refined sugar manufactured, on condition that the factories pay $5 per ton to the farmers for the beets. The governor vetoed the bill.

Some years ago Nebraska passed a bounty law devised to encourage

farmers and manufacturers; the following legislature refused to make the appropriation necessary to carry out the enactment, and the law was finally repealed.

In Minnesota the legislature passed the bounty law offering 1 cent per pound for all sugar manufactured in the State, and limited the expenditure in this direction to $40,000, distributing this amount pro rata among the factories earning the same. The bill was vetoed by the governor, but was passed over his veto and became a law of the State.

Other States in which factories are not yet established have bounty laws on their statute books. South Dakota, for instance, offers a bounty of 1 cent per pound. In Iowa the legislature passed an enactment remitting the taxes on all investments in sugar factories for a a period of ten years. In the State of Washington, where a factory is located at Spokane, 1 cent a pound is offered for all sugar manufactured. The total amount is limited to $50,000. The operation of the law is limited to a period of three years, and to factories which shall be completed prior to November 1, 1901.

Michigan has been the storm center of the objection to this bounty system. This probably grew out of the fact that nine factories were put in operation in Michigan in the short space of two years. The legitimate claims of these factories under the law seemed an enormous drain upon the State treasury. Under the terms of the law it was provided that factories were to receive 1 cent per pound for all sugar manufactured. The act appropriated $10,000 for the payment of the bounty and provided that any excess above that should be paid out of the general fund by warrants drawn against the same. The first factory built in the State was that of the Michigan Sugar Company, which drew the bounty for the first year, 1898, absorbing the $10,000, and then put in a claim for the balance from the general fund according to the law. Eight other factories were constructed and put into operation for the campaign of 1899. These nine factories produced 33,150,873 pounds of sugar, and under the terms of this law were entitled to $331,508.73.

The people of the State were confronted with an enormous drain upon their State treasury. These factories operating for the first year were late in beginning. They were in the experimental stage; they were working on the first crop of beets ever produced by Michigan farmers. Owing to all these causes it is probable that the factories did not produce sugar equal to half their capacity. Thus if no additional factories were built, the demands on the State treasury might reach something like $700,000. The following legislature undertook to amend the law by inserting one-half cent per pound instead of 1 cent, as under the old law; the governor had insisted in his message that there should be a clause limiting the maximum amount that could be paid to any one factory to $25,000. The legislature refused to take

this view of the case, and the governor vetoed the bill. This left the old law in force. The attorney-general rendered an opinion that warrants could not be drawn on the treasury for this purpose; that the object was not one for which a tax could properly be levied. The sugar factories insisted upon their right under the law. The matter was carried through the courts and finally it was decided by the Supreme Court that the law was unconstitutional and the attorney-general's opinion was sustained.

The States of New York and Minnesota are continuing to pay bounties and to encourage the industry in this way. It is usual for States offering bounties to require that factories pay an additional amount for beets, usually $1 a ton over and above the ordinary market price.

Is there any actual necessity for the offering of a bounty? There is sufficient profit in the investment, where right conditions prevail, without this additional encouragement. The offering of a bounty has more or less of a tendency to stimulate the location of a factory where the same might not have gone had everything depended upon the natural advantages. The future of this industry depends largely on the location of factories in places where they can be sustained upon the natural resources. If all the States keep their hands off in this matter, the first factories will go to places showing the best conditions for maintaining them. One failure will do more to discourage than many successes can do to encourage the industry. If any encouragement is to be offered, it should be done by the General Government, so that factories shall be left free to seek the places presenting the best facilities and natural inducements.

It certainly appears to be a hardship that a factory should be constructed in any particular State under the implied contract that said State will pay a bounty for a certain period, and then, when the factory shall have been built and the investor's money is tied up, the State should fail to keep its agreement. In the case of the State of Michigan much of the capital now invested in the sugar industry had been already organized and employed in other lines. The timber resources of the State were failing. In many large centers of the lumber industry the mills had closed for want of material to work upon; the fires were out and the capital was idle; the capitalists were looking around for something else to introduce in the place of their waning lumber industry. The State came forward and offered encouragement in the way of bounty on beet sugar. Factories were built immediately, expecting to participate in this State bounty. It was believed by investors that by the time this bounty expired by limitation the factories would be so thoroughly installed that they would be able to continue successfully without it. Under the court's decision they will of necessity have to succeed without it, if at all. This should have been the understanding in the start.

BONUSES AND EXEMPTIONS.

The promotion of this industry is attempted through a great many plans, ways, means, and, in some instances, "schemes." The method adopted by those imbued with public interest or local pride has already been presented. Most of those participating in public meetings and conventions, as well as those who write and lecture, are imbued with the idea that the industry would benefit the community as a whole. Such persons are working simply for the public weal.

There are persons of another class who help to stimulate local interest and organization because they would like to be connected in a practical way with the industry by investing capital and participating in the organization of the concern. Architects and designers of factory machinery also assist in the promotion and stimulation of local action and the investment of capital. The work of these classes usually promotes the industry in a legitimate way.

There is still another class of promoters whose operations are more confusing than beneficial. This is a class of men who assume to be experts on the subject of this industry, and usually claim to represent large amounts of capital, which is not apparent. They go into a community, agitate the question, hold public meetings, and arouse public sentiment, by giving the impression that they have unlimited capital behind them, and that they are on the eve of starting a sugar factory in the community. When public sentiment is aroused to a sufficient pitch, they make a proposition that if a certain bonus shall be paid by the community—usually so much land, and so much in money, running up into the thousands of dollars—they will secure the capital for starting a factory. Then, perhaps, the city authorities meet, remit the taxes, grant franchises, and guarantee privileges. The people organize, raise funds to buy the land, and to pay the extra in cash. Sometimes it is stipulated that the local community is to subscribe for a certain percentage of the stock. Sometimes it is required that the farmers shall subscribe for a considerable amount of stock and pay for the same in beets, so much each year. The local organization is required to secure contracts for so many thousand acres of beets for the factory. In many instances this is purely the work of bonus hunters with nothing back of them. They take the contracts from the farmers, the offer of a bonus in land and money, the franchises, privileges, the remission of taxes granted by the city, and start out to hunt up some capitalists who will take this job lot of public gratuities and give in return a good round sum, and possibly a position in the local organization.

It is not charged by the writer that all the promoters who travel around investigating conditions and interesting local communities are doing so without any definite means of accomplishing what they pretend. But it is asserted that this is true in many cases. In cases

where a community is once "taken in" thus, it is hard to arouse them again to the point of considering a really meritorious proposition where it is legitimate and bona fide.

When propositions are made by promoters, local communities, before they give up their time and energy and involve the public in consideration of the project, should first demand definite credentials. The promoter should show that he is able to carry out his side of the deal when the community shall have met the conditions proposed. The writer can not refrain, in this connection, from stating his belief that any considerable amount of bonus is entirely unnecessary. The offering of franchises and privileges and the remission of taxes do not seem to be objectionable, provided the community or municipality does not find it burdensome. The prospect of success in the proposed enterprise should be sufficient to induce the investment of capital without the additional encouragement of a bonus. It may be that concessions of a certain amount of land would not be burdensome, but the community should never be called upon to pay a large free cash subscription.

The question of local subscriptions for stock is another matter, simply a business proposition, provided such stock entitles its holders to participate in every way on an equality with all other share holders. This is a method of encouragement that may be recommended as wise and safe, provided conditions justify the belief that the sugar factory will be a paying enterprise.

If the entire amount of capital could be secured in the community, ideal conditions would prevail so far as capitalization is concerned. This would combine the entire influence of those interested in the success of the concern, and produce united energetic effort. This, however, is not possible in many instances, and a factory need not fail of building on that account.

Sugar-Beet Seed.

The growing of sugar-beet seed is an intricate process if the best results are to be obtained. No novice should engage in this enterprise. The sugar-producing quality of the beet has been built up through long years of careful study and work. It is the result of scientific breeding and selection. When the manufacture of sugar from the sugar beets began, they were considered of good quality if they possessed a sugar content of 6 to 8 per cent. At the present time the usual requirements for factory purposes is that sugar beets shall contain at least 12 per cent in sugar with a coefficient of purity of 80. All the localities now growing sugar beets for factory use in this country will show an average over these requirements. In some of the regions of California, notably the southern part, the averages are maintained as high as 16 per cent throughout the campaign. It quite often hap-

pens in cases of individual beets, especially where they are grown for experimental purposes, that they will run as high as 24 per cent sugar. This increase in the sugar content in the beet has come about in no haphazard way. It is purely the result of skillful effort and scientific direction.

Only those beets were selected as "mothers" for growing the seed which showed a high sugar content and coefficient of purity. The seeds grown from these beets were planted, and from the resulting crop beets were selected that showed the same high qualities, and seeds from these were planted for a third crop. This process was continned through a series of five years before the seed was considered fit to place on the market.

HOME PRODUCTION OF SEED.

It is gratifying to know that the industry of producing sugar-beet seed in this country is growing quite rapidly. It was early learned that the seed question was of considerable importance. When the industry started, and for some years thereafter, all the seed used was imported, mainly from Germany and France. Every year now adds largely to the home production of this commodity.

We have thirty-two factories in operation in this country, most of which are of large capacity; others are constantly building; we possess the largest factory in the world, and others that will compare favorably with the largest in Europe. It is entirely competent, in view of this fine start in the installing of this industry, that we should grow our own seed.

It is important, however, that those who undertake this task should be fully aware of the seriousness of the undertaking. The sugar beet of high sugar-producing quality was developed by exactly the same methods as the Jersey cow or the high-bred horse. It can be readily seen that a system like this requires careful attention, scientific knowledge, and expert direction. Not every seed grower could produce good sugar-beet seed, as is done in the case of other vegetables. He must first equip himself with the knowledge and with the facilities in the form of a laboratory and apparatus, which are necessary and expensive, in order to successfully carry on this enterprise. The beets must be kept up to the same high standard that has been maintained by the growers in Europe. When a farmer secures his seed from the producer in this country he must have the same assurance that they possess the quality. The value of his crop depends upon the sugar-producing qualities of the seed. The sugar manufacturer is also interested in the quality of the seed, because his success in making sugar from the beets depends to a large extent on the available sugar in the beet and the purity of the juice. These are qualities inherent in the seed. Breeding and selection must be strictly observed. The time

that has elapsed since sugar beets have been brought into requisition for producing sugar is relatively short compared with the time required to fix a habit or tendency in the nature of a plant.

The business of producing sugar-beet seed is the work of a specialist and not that of a common seed grower. If the methods here outlined are observed, the time is ripe and the opportunity is inviting for home production of seed. There will be a constant and a growing demand for this product. There is no reason why the home product should not be equal or even superior in quality to the foreign seed. It would certainly inure to the benefit of the beets if they could grow under the same conditions as affected the life and growth of their progenitors.

INSPECTION OF IMPORTED SEED.

So long as we are compelled to secure a considerable amount of our beet seed from Europe, some system ought to be devised for examining and testing the same. The Government has been giving careful attention to the importation of fruit trees, scions, etc., in order to keep out the infection of diseases and insects. It seems that some scheme should be devised for inspecting our importations of beet seed. While the consumer should be left free to import such varieties as he may deem advisable, yet those importations should pass through the hands of a competent inspector. This system would have a very salient effect on the quality of the seed brought into the country. The very fact that the seed has to pass through inspection would have a tendency to eliminate a large part of the poor seed from the original shipment.

The things most important to be secured by inspection would be (1) the quality of the seed for producing high-grade beets; (2) the vital or germinating power of the seed; (3) the cleanliness or freedom of the seed from obnoxious grass or weed seed.

The Molasses Problem.

Molasses is a by-product of the beet-sugar factory that has given the management considerable concern and a vast amount of study in the past. About all that can be said of it at the present time is that it can be classed largely as one of the wastes of the factory, and one of no inconsiderable moment. It contains the sugar which it has not been possible to separate from the other elements contained in the beet juice. Sugar beets often show as high as 16 per cent of sugar on the average; but it is not possible to secure more than 12 per cent in sugar. Indeed it is good work if a factory can secure 10 per cent of granulated marketable sugar. The balance of the sugar originally in the beet is to be found largely in the molasses.

The molasses also contains the salts and impurities originally in the beet. It is of a thick consistency, black, bitter, and very unpalatable. It is a matter of considerable importance to the factory, however, in

that it represents so much waste of time and product. Here is an inviting field for investigation and study for the man who desires to make himself famous as well as useful. How can this item of waste in the molasses be eliminated? How can the sugar be gotten out of it? By what process can this be done without the expense eating up the profits? If the sugar can not be gotten out, how can the molasses be made a valuable by-product? If it can not be made useful directly, how can it be made a raw material in the manufacture of some other useful commodity? In these questions is involved one of the leading problems of the sugar makers. The opportunity exists for materially cheapening the process of making sugar and increasing the output from a given amount of beets, provided this sugar can be secured. Considerable has been accomplished in this direction. It has been done largely through introducing more effective methods in securing the sugar from the beets. It has been done by taking the molasses after one process is completed and beginning on it with an entirely new process. Of these different processes we have the Steffin, the osmose, the crystallization-in-motion, and others. Nevertheless it remains a fact that, with any and all these methods, the factories have a large amount of molasses to dispose of in some manner.

It is quite common to hear that at some particular factory this problem is handled quite successfully. Such reports are heard only at a distance from the factory. This great saving vanishes as the factory and the facts are approached. This handling of molasses is the will-o'-the-wisp of the sugar business. It is the mirage that always disappears on investigation. No doubt most of the sugar has been extracted from the molasses at some of the factories, but it has been done at such an expense that it is probably not profitable.

The molasses has been turned to account in a great many ways. Methods have been devised for distilling alcohol, and this might succeed and be profitable were it not for the internal revenue which the distiller of alcohols and high wines must pay in this country. It has been used as a material for making shoe blacking, and other things. It has been mixed with the pulp in certain quantities for feeding to stock. In foreign countries it has been mixed with the pulp and dried, and this product has been shipped out as is oil cake in this country. Owing to its tendency to physic animals, it can constitute only a certain portion of the ration. Probably the best that can be said concerning the usefulness of molasses is that it can probably be used to a certain advantage in feeding it with pulp.

Conveyance of Juice in Pipes.

There is a limit to the distance at which it is profitable or desirable to deliver beets to the factories by means of wagons. This distance is governed by the kind of road over which these beets are to be con-

veyed. Provided the roads are such that two and a half to three tons may be delivered readily with a four-horse team, the distance is generally placed at 10 or 12 miles. Any beets produced beyond this limit should be taken to the railroad station and delivered to the factory in cars. The limit for profitable delivery of beets by means of railroads is generally placed at from 50 to 75 miles. This depends upon the freight rate charged by the road for this kind of freight. The factory management usually makes an endeavor to get the rate down as much as possible. It takes the matter up early with the road and uses the location of the factory on the particular road as a leverage for securing a contract with the road governing the cost of freight.

Even the facilities of railroads for furnishing beets from the surrounding territory are limited. Outside of the wagon limits, and the strips of land bordering the railroad each way for 50 to 75 miles, the farming lands are unavailable. Even were it possible to raise sufficient beets in the territory indicated, difficulties often arise, crippling the work of the factory. Washouts often occur, delaying the beets; the beet crop matures and is ready for delivery at a time when much other farm produce is also calling for transportation; cars become scarce, and the factory becomes hampered in its supply of beets; sometimes it is compelled to shut down until the sheds are filled. All this is unfortunate and expensive to the factory.

A system has been devised for delivering the juice instead of the beets. This is accomplished by means of a pipe line laid in the ground at a sufficient depth. This pipe line is of steel capable of standing high pressure. In different directions from the factory, slicing stations or plants are established. These plants are auxiliaries to the main factory; they are equipped with sheds and all the outer equipment for a factory in addition to the beet slicers and the diffusion cells for extracting the juice. They also have heating facilities and limers for the purpose of preparing the juice for transportation. The juice is forced through the pipe line by means of pumps (possibly by gravity) to the main factory. Here the juice is treated exactly the same as that extracted from the beet in the main factory itself. This method has been tried in Europe, and there is more or less conflict of opinion as to the results. It is being extensively and successfully tried by the Utah Sugar Company, located at Lehi, Utah. This factory is under the management of Thomas R. Cutler. It was through his investigations of this method in Europe and his representations to the management that this system was introduced. We quote some of the things he has to say on that subject:

Last year we enlarged the central factory at Lehi and put in an auxiliary plant at Springville, 22 miles south of Lehi, and another one at Bingham Junction, 19 miles north of Lehi, giving us a double pipe line of 41 miles. We understand that we have the longest pipe line for beet juice in the world, 22 miles in length from Spring-

ville. We also trebled the capacity at Lehi so that we could work at the central plant the juice from 1,200 tons of beets per day, and we have run that many beets through several days this last season.

I am not able at this date to summarize the working expenses of our auxiliary plants, or to say whether they are conducive to economical working under general conditions, but the conditions in the interior the last two years in regard to facilities for the carrying of our beets have been excruciating, and we were compelled to take some steps so that our farmers could get their beets to the central factory. No other way offered itself that seemed to meet the emergency except that of building auxiliary plants. We pay the same price per ton as when delivered at the central factory. Our prices for 1900 were $4.50 per ton for beets containing not less than 14 per cent sugar with a purity of 80, $4.25 for beets containing 13 per cent sugar with a like purity, and $4 per ton for beets containing 12 per cent sugar with the same purity. The average quality of the beets was 14.1 per cent, with a coefficient of purity of 82. Our entire loss was only 2.8 per cent. We used the osmose process on our low-product molasses.

There is a strong probability of our putting in another auxiliary plant or cutting station at a point on our pipe line south about 14 miles from here this spring, so as to have it ready in time for this season's work, and this will be done for the same reason that we built the others, viz: On account of the extreme scarcity of cars at our disposal during the months of September, October, and November.

It can be readily seen that if this system shall prove a success, it will change materially the status of the industry. Some of the objections offered are that the quality of the juice will deteriorate in reversions; that the liming of the juice will interfere with its conveyance, but Mr. Cutler, quoted above, says: "We feel that we can say, however, that with us they (pipe lines) are a perfect success."

This plan makes it possible to establish a large factory (as in the case of the Utah factory) at some central point. And then at distances convenient for the purpose, slicing stations can be installed. The people living in the vicinity of these stations have most of the benefits enjoyed by those near a regularly equipped factory. The farmers have the convenience of delivering their beets in wagons and returning home with loads of pulp for feeding their stock. A farming community that has not the capital to build a factory or the opportunities to secure outside capital may instead secure one of these slicing stations.

This plan will have a great tendency to increase the capacity of the main factory. Almost any company will be in a position to inaugurate this auxiliary system by increasing its capacity for working the juice. The system seems inviting, providing it is practical to convey juice in this way. It would certainly be cheaper to force the juice the same distance than to haul the beets by any method of conveyance.

It is a system that augurs much under our peculiar conditions if it shall prove a success, which seems probable. At least it is one of the industrial problems to be worked out in this country. It may have much to do with the future of the industry. It is one worthy of careful consideration.

IRRIGATION.

We have vast areas of land in this country that is peculiarly susceptible to reclamation through irrigation. Most of this land proves itself to be good soil for the production of sugar beets, provided moisture is secured. We began the business of growing sugar beets with very little information as to the effect of irrigation. We have worked out the main facts ourselves.

Utah has offered a large fund of information on this subject. The original settlers of Utah began by raising products under almost desert conditions. They devised and put into operation a system of irrigating ditches that is a model. Under their system small farms are the rule, and the resources are carefully husbanded. The sugar factory was installed in a section having small, carefully tilled, irrigated farms. Previous experiments had shown that it was possible to grow sugar beets by irrigation. This question was put to a practical test. There is sufficient rainfall to sprout the plants and start them on their growth. In order to complete the crop it is necessary to resort to irrigation. The amount of irrigation depends upon the amount of rainfall, and it is only resorted to when necessary. The experience of eleven years has shown that sugar beets can be successfully produced by irrigation, but there are many things in irrigation that must be studied and applied with reference to this particular crop.

New Mexico followed Utah's example. Sugar beets have been grown in the Pecos Valley, where the necessity for the application of moisture through irrigation is greater than in Utah. The results of this test also show that the crop can be produced in this way.

Next came Colorado, with the establishment of a factory at Grand Junction, where a large part of the moisture was applied through irrigation. Factories were also started in the Arkansas Valley, Colorado, at Rocky Ford and Sugar City, where irrigation will again be put more or less to the test. The lack of sufficient rainfall in California has opened up this question there. Every year adds more to the amount of territory where sugar beets can be grown through irrigation, if necessary, and where they are actually grown in this way.

The resources for establishing artesian wells are being investigated, with a view to securing an available supply of moisture for growing sugar beets. Problems of storing water in the mountains, to be used in the irrigation of crops in the valleys, are becoming matters of interest to the National Government. Special features of applying irrigation to sugar-beet crops are questions for careful study throughout these arid sections.

The really hopeful feature of the present tendency in factory building is the future which opens through this industry to the arid parts of our country. As experience with irrigation has accumulated definite knowledge of results in growing sugar beets, it has been found that

heir production appeals more for its introduction than does any other product. Beet culture presents a twofold claim on this region: (1) It as been shown that with sufficient moisture a greater success can be nade with this crop than with any other; (2) at the same time it has been shown that the sugar beets grown in these arid regions during he past year (1900) have maintained a higher average sugar content nd purity than those grown any place else. This gives the farmers of these sections a new crop resource which seems fitted in every way to reach its best results under their peculiar conditions. It adds to their rotation and will affect very materially the resourcefulness of the arid section.

The history of agriculture and mining in these Mountain States presents a very close analogy. The first mining of the country was confined to the rich outcroppings, only the rich ores being worked. In this way the whole mining region was skimmed. Later new processes were discovered for working lower-grade ore, and the old dumps and abandoned claims became even more valuable than the pioneer rich mines. Original agriculture in these States followed the streams and selected spots where moisture would prevail. The large fertile valleys, more arid, were avoided. The science of irrigation has progressed. Flowing streams have been tapped and the water turned onto these arid plains, showing results far more important than those from the lands originally cultivated. These results rival the best in the Mississippi Valley. In fostering the agricultural industries and seeking for crops that are suitable for the arid region, the Government has builded better than it knew. In attempting to better the condition of its citizens, putting them in position for establishing lucrative farms and prosperous farming districts, it has greatly enhanced the value of its own possessions.

In the settlement of the country these arid lands have been avoided on account of their lack of moisture. A large portion of this land still belongs to the Government, and has hitherto served no purpose except that of grazing. Several acres of land are required for grazing one animal. These lands can be made and should be made more productive. Throughout the length and breadth of these arid regions vast quantities of water are running away to the sea. The plans devised at present for irrigating take their water from running streams. This would utilize during a part of the year—the growing season—some of this water. During the other part of the year and at the time of the heavy rains and movement of the snows by melting, the water escapes through its various channels into the sea. These waters should be stored and let down into the valley gradually, thus multiplying their utility many times and multiplying as many times more the amount of land that can be brought into usefulness. Wherever land is recovered in this way and given a permanent, sufficient, available supply of water for producing crops, its value is enormously increased.

The Feeding of Pulp and of Beets.

Here is another great opportunity for utilizing the benefits of the sugar industry. Sugar beets are a valuable crop to grow on a farm for their feeding value alone. After the sugar contained by the beet is extracted, they are almost as valuable for feeding purposes as they were before. The idea naturally presents itself that the farmer would find it especially profitable to grow the beets and sell the sugar they contain to the factory and have the pulp for feeding. In previous reports I have had considerable to say on this subject. I have offered the evidence of the most extensive and successful stock feeders in this country, have given the results of exhaustive experiments which they have made, and have shown that pulp is the very best food in the ration of the dairy cow. After stock has been trained to eat it, there is nothing that gives as good results in all kinds of general feeding as a certain amount of this sugar-beet pulp.

PULP FEEDING.

In my report for 1899, attention was called to the results of large feeders at Grand Island, Nebr.; also to those obtained by the Standard Cattle Company at Ames, Nebr., probably the largest feeding enterprise in this country. It was shown that after experimenting with pulp in feeding sheep and cattle, this concern through its stockholders stimulated the organization and building of a sugar factory in that vicinity. The prime object to be attained was the securing of the pulp for feeding which this factory would turn out. After sugar beets have been through the factory there remains in this by-product about 45 per cent of their original weight. This factory at Ames is one of 500 tons daily capacity. It, therefore, turns out in its daily run over 225 tons of pulp. This pulp is easily stored and preserved. In this particular case, it was usually hauled out into the feed lots like other coarse feed and consumed daily. If necessary it will keep for two or three years and still be valuable for stock feed. The action of this company is a strong argument in favor of the desirability of pulp for stock-feeding purposes. Its utility must have appeared great to cause a concern of this kind to invest capital to the extent of $600,000 or $700,000 simply to get this product. Strongly as it appeals to those posted on the subject, it has been a strange fact that the farmers at large have been so slow to recognize its value. It has been mostly the large feeders or companies organized for feeding purposes who have taken advantage of this source of securing desirable and cheap feed.

Many of the factories have had in the start to offer their pulp at 10 to 35 cents a ton, and in some cases they have given it away in order

to get it out of the way. In isolated cases farmers took up with the proposition readily, but it seems it has taken a great deal more time than should have been required to convince the ordinary farmer.

The American Beet Sugar Company, of Oxnard, Cal., has itself taken hold of this question, built large stock yards and is feeding a large number of cattle from its factory.

When we compare the action of the Oxnard factory with that of the Standard Cattle Company at Ames, Nebr., we can comprehend the strong mutual relation that exists between the sugar manufactory and the feeding industry. One, a feeding concern, builds the factory to get the pulp for its cattle and sheep. The other, a factory concern, establishes immense stock yards and buys up a large herd of stock in order to dispose of the pulp. It only shows that information is the thing required.

In New York almost every farmer is engaged more or less in dairying. He lives in proximity to some large trade center. The people of this center must be supplied with milk, butter, and cheese. At these centers are located factories working on cereal products. They are manufacturing starch, beer, and other products. They have a large output of by-products which is returned to the farms for feeding purposes. This refuse has shown itself through years of experience to be especially valuable as food for the dairy cow. The farmer is educated as to its utility. In order to produce his milk cheaply and successfully he must resort to this kind of feed, as does every other farmer.

The farmers of New York were especially inclined from their past experience to accept the proposition that sugar-beet pulp was a good feed. When the factories started in New York it was with the advantage of being able to readily dispose of their pulp. In the beginning the factory at Binghamton was able to turn off its pulp at from 50 cents to $1 per ton. It will be able to get more per ton as the demand grows stronger. All the factories that have been established in other States will finally be able to sell their pulp. The demand will grow and the price will increase. They will have to educate the farmers in their vicinity to the point where the New York farmer began.

Mr. Robert Oxnard, at a banquet recently given at Rocky Ford, said, among other things, in speaking of the benefits which would accrue from the establishment of a sugar factory:

> It means that the cattle feeder and the sheep feeder are given at a nominal price one of the best fattening and dairy foods known. After the sugar is extracted the pulp is almost as good as the beet itself for cattle feed, and no farmer is doing justice to himself who does not take his proportion of pulp and, after turning off a few fat steers or sheep at a good profit, return to the land in the shape of manure that which he took from it.

The reporter for the Beet Sugar Gazette, Chicago, Ill., has the following to say of pulp feeding at Los Alamitos, Cal.:

> Live stock is in excellent condition, especially that which has been fed upon pulp. The best effect of this food was shown in the great improvement made in the Los Cerritos Company's herd of 150 cows, which increased in weight of milk 160 per cent, with an increase of 0.6 per cent in the content of butter fat. The pulp is fed to the cows in troughs, where they are allowed to lick it up at will, allowing about 80 pounds per head; for roughness they are fed alfalfa hay. These two foods alone constitute their ration, upon which the cows not only improve in product, but keep in better health, and some of them even lay on flesh. The pulp is relished equally as much by hogs, a large number of which are kept in connection with the dairy.

It is unnecessary to add testimony in support of the proposition that sugar-beet pulp is valuable for feeding purposes. This is generally accepted now by those best posted in agricultural subjects. Wherever a sugar factory has been established, enough of this by-product is fed to thoroughly demonstrate its utility as food. The agricultural press, the general newspapers, and the leaders of agricultural thought will keep this matter before the public until it will be thoroughly advised thereon. These factories will all eventually dispose of their pulp at a remunerative figure, or else it will be returned to the farmer under some such arrangement as is now adopted by the creameries with skimmed milk.

In any case the farmer and the manufacturer are bound to be mutually benefited. Pulp feeding is one of the strong salient points in favor of the beet-sugar industry as against the encroachment of cheaper sugars produced in the Tropics. The stimulus it gives to the stock and dairy industries must be counted in favor of the general resources of the beet-sugar industry.

This problem will have been fully worked out when the value of this by-product is as thoroughly appreciated as it is in the sugar-producing countries of Europe. This will be when every consumer of feeding commodities appreciates the value of pulp for food and is making a demand therefor. In those countries, stock is not only fed pulp in the manner described above, but machinery is installed in the factory for preparing it and sending it out in convenient form. The pulp is dried and pressed and sent out as is the oil cake of the flaxseed-oil factories in this country. It is very much reduced in bulk and weight, and its feeding value is increased. It can be readily sent to the retail feed stores and doled out in parcels, as is now done with bran, oil cake, etc. This dried, specially-prepared pulp sells on the market for $1 per hundredweight. This brings the citizens of cities, towns, and villages in as customers for this by-product of the sugar factory.

The writer is unable to state whether or not the dried product is more available, palatable, or desirable than the fresh pulp. It is a fact, however, that the demand is very strong for it in Europe and it holds a very high place on the list of feeding products on those

markets. If the same shall be the case in this country, this general demand will very much increase the usefulness of pulp, and make it still more a factor in the question of sugar producing. We are not long to be left in the dark. Several of the companies are now installing departments and apparatus in their factories for drying this pulp. Some of them are accepting the machinery with the proviso that it shall be retained as a feature provided it is successful in turning out a product that is desirable and useful. Among the factories at which this matter is being tested are the ones at Binghamton, N. Y., and Holland and Bay City, Mich.

USE OF BEETS IN FINISHING CATTLE.

Prof. C. F. Curtis, of the Iowa Experiment Station, says in the Beet Sugar Gazette:

From our experience here in the use of beets in finishing cattle of high quality for the block, I have no hesitancy in saying that the introduction of roots and the beet product into our fattening rations will result in a higher and more desirable finish, and a vastly better product. All of the cattle that have been marketed by the Iowa station and killed with such good results have been finished on a ration consisting in part of roots. Some of these cattle were on feed a year, and carried to an unusual degree of ripeness, and yet not one of them was what might be termed overdone. When one of our best carload lots was hanging in Swift & Co.'s cooling rooms the head cutter and manager remarked: "Look at them. Did you ever see as highly finished a bunch of steers without a patch on the carcasses anywhere?" The use of root crops enables the feeder to make a better and more desirable carcass of beef than can be made on dry feed alone. The animals fed roots are mellower to the touch, evener in their flesh, and in better bloom than it is possible to obtain on dry feed, and the gains are larger and more economically produced. The same advantages apply even in greater degree to the use of roots in the ration for breeding stock. It will pay to establish root culture on the stock farm, whether we make our own sugar or not. I spent a day on the farm of the Standard Cattle Company at Ames, Nebr., where 3,000 cattle were on grain. Mr. Allen, the manager, was then feeding beets quite extensively. These were purchased from neighboring farmers at $1.50 per ton, and considered profitable feed at this price when corn could be obtained at from 18 to 20 cents per bushel. I never saw cattle appear to be doing better or in a more thrifty condition. Mr. Allen also states that until they began feeding roots they were troubled with hog cholera, but since then they have not had it.

FERTILIZING AND CULTIVATING THE SOIL.

One of the strong points in favor of beet-sugar production is that a large area of our country is capable of producing the crop without the aid of anything but the ordinary barnyard manure. In Germany and France it costs $20 to fertilize an acre of ground by the use of commercial fertilizers. In the Hawaiian Islands it costs $22.50 per acre for fertilizer in order to produce a crop of sugar cane.

We have considerable scope of country devoted to the raising of sugar beets upon which nothing can be successfully grown without the application of more or less commercial fertilizers. It may be demon-

strated that all the soil devoted to this use could be made more responsive by the use of some of these commercial fertilizers. As a general proposition, it can be stated that our soils are considerably less expensive in the demand for fertilizers than are those upon which the sugar beets of Europe are grown. However, it is more or less an open question how much and what kind of fertilizers should be used here. This is a subject which is constantly under investigation. The solution of the problem will affect more or less the quantity and quality of our future beet crops.

There is another item that will have a strong bearing on the future production of this crop, and that is the kinds and methods of cultivation. It is being pretty thoroughly demonstrated that the method of cultivation adapted to one section will not answer the purpose in another. It is a matter of experiment to know just what kind of cultivation should prevail in any particular section. In some places deep plowing seems absolutely necessary; in others this is not a real requirement.

There are some who insist that sugar-beet land should be selected from the stubbles and meadows; that it should be plowed the year before, and replowed and harrowed just before planting. It is claimed by them that the fallowing of the land for a certain time, followed with freezing, puts the soil in the best condition for planting sugar beets. Others claim that the very best land that can be selected is that which has been in corn the year previous. They say that, while it takes a little more trouble to remove the stubs, yet the cultivation the soil received the year before is necessary to give the best results with a sugar-beet crop. Of course this argument would apply to most of the other cultivated crops. The writer's observation leads him to believe that both these classes are right. They are both giving expression to their actual experiences. The variance in methods arises from the different requirements of the different sections. For instance, large areas of sugar beets are grown in this country where freezing does not obtain at all. And in other sections of the country, especially in the Mississippi Valley, results are obtained by rotation that farmers in another section would have to obtain by fallowing and plowing. The kind of cultivation needed must be settled for each district according to its own peculiar requirements. This problem is now under investigation, and eventually each farming district will have its own "right way." The solution is being worked out on the farms. Finally, we shall have standards governing the kind and method of cultivation, and the sugar industry will be greatly benefited by the information obtained.

In discussing the future of the sugar industry from the agricultural side, and giving the list of benefits that must result from experience and practice, we must not overlook the lasting benefits to be derived by the soil itself from intensive cultivation. Whatever be the method

of cultivation prevailing, there are a few points that must always be observed in the cultivation of sugar beets. The ground must be kept clean and free from weeds; it must be thoroughly plowed and cultivated; it must be kept in a high state of fertility through the application of barnyard manure or commercial fertilizers.

In the harvesting of the crop the ground is again stirred. The refuse of the crop, if it is not fed, such as the tops and crowns, containing valuable fertilizing elements, are left on the field. This is usually the case. These readily decay and enter again into the fertility of the soil. The ground, through its numerous cultivations and stirrings, is rendered very soft and pliable. Being free from weeds and grasses it is in a fine condition for producing crops. By a proper system of crop rotation the farmer is constantly bringing other parts of his land under this high state of cultivation. Every succeeding crop teaches the benefits to the farmer to be derived from intense cultivation; finally it becomes the rule of his system. Of the benefits which come from installing the beet-sugar industry, we must count soil improvement by high cultivation an important item. It is an item that will in the future inure to the general benefit of agriculture throughout the country.

The following are the deductions of the Michigan State Experiment Station from the experiments with sugar beets in 1899:

Subsoil plowing practiced immediately before sowing the beets, owing perhaps to the severe drouth which followed, resulted in the complete loss of the crop.

Coarse manure applied some two months before sowing the beets resulted in increased yield and beets of a normal percentage of sugar.

Carefully prepared home-mixed fertilizer gave higher yields and better beets than stable manure.

Nitrate of soda alone gave no marked increase in yield, but in combination with other elements generally increased the yield with a normal percentage of sugar.

In every case nitrate of soda gave higher yields than sulphate of ammonia.

Wood ashes and salt increased the yield of beets slightly.

One ton of air-slaked lime per acre increased slightly the yield of beets on the uplands without affecting the percentage of sugar.

On muck land, one ton of air-slaked lime per acre in combination with other fertilizers decreased the tonnage 11 per cent and reduced the sugar content from 9.64 to 7.68 per cent. When lime was applied alone on muck land, increased applications increased the tonnage of beets but decreased the percentage of sugar.

Early planting gave larger yields and slightly higher percentage of sugar.

Clay loam soil produced the largest tonnage and the highest percentage of sugar; followed by other soils in the order below, except that the tonnage on muck is next to clay loam: Sandy loam, sand, clay, muck.

During the past season there was a slight falling off in sugar content of growing beets from October 19 to November 23.

Conservation of Factory Utility.

The time for an active campaign in the manufacture of sugar from beets is usually placed at from three to four months. The fact that the factory is idle the rest of the year with its large equipment of

machinery and its large investment of capital seems an expensive feature of the business. This question is pertinent: "Why can not these factories employ their time during the rest of the year in some other line incidental to the manufacture of sugar?" This question is constantly occurring and recurring to those who investigate the subject. This question has been the subject of careful consideration by some of the manufacturers. At the present time we have organizations that are projecting plans for the establishment of beet-sugar factories so arranged that the factory can be made useful most if not all the year. Owners of some factories already built are studying these propositions.

The Hawaiian sugars must be refined in this country. All our importations are in the raw form. The question has arisen: "Why not, in the original plan of the coast factories, include facilities for refining on a large scale, so that the furnaces, engines, and many other parts of the factory, as well as the labor, might be employed continuously in refining sugar when not manufacturing it?" At Omaha, Nebr., an organization has been considering the feasibility of erecting a factory that will manufacture sugar from beets during a regular campaign, and then utilize its resources during the rest of the year in the manufacture of starch. In Illinois, the building of a sugar factory that can manufacture glucose during this idle period has been seriously contemplated. If factories can be utilized in such ways throughout the year, it will cheapen to a considerable extent the production of sugar.

Crop Conditions and Factory Operations during 1900, by States.

The results of agricultural operations should always be viewed in the light of the conditions under which they have been achieved. This is especially true of sugar-beet culture. It is therefore necessary, in order to estimate the degree of success achieved in the beet-sugar industry during 1900, to review the climatic and other conditions under which the crop of sugar beets was produced. This will now be done, taking up the States in alphabetical order.

IN CALIFORNIA.

In growing sugar beets, California has climatic conditions peculiarly her own. The cropping of sugar beets in this State began on what is known as the damp lands. These have natural subirrigation, or underseepage, from which the beet crop draws a supply of moisture during its growth. The first prerequisite is that there shall be a large rainfall in the winter to thoroughly saturate the soil, not only that upon which the beets are planted, but that of the uplands and mountains. This winter saturation serves two purposes: (1) It supplies sufficient moisture for sprouting the beet seed, as they are planted in late winter

or early spring; (2) it causes the subirrigation of the beet fields during the growing season.

If the beets receive a good rain or two after they have fairly started, the crop is assured in these sections. There is no question about the resources of the soil. The results of many years have shown that these soils will produce an abundant crop of high-grade beets whenever the moisture is secured.

The one source of encouragement that remains to the residents of southern California is the fact that the record of a long series of years indicates that the rainfall in the last three years has been abnormally low. The farmers confidently look for a return of conditions more in keeping with the history of the State. So far as the sugar-beet crop is concerned, it is not especially desirable that the average rainfall per annum shall be large; it can get along with much less rainfall, provided the same comes at the proper times to supply the needs of the crop.

The winter saturation for this purpose in 1900 was not at all satisfactory in California. As a result, not nearly so large an area was planted with sugar beets as might have been under more favorable circumstances, and the earlier beets planted did not make a favorable start. In the latter part of April and the early part of May the precipitation of moisture was about 3 inches in southern California. This was followed by a good rain about the 1st of June. The results of these rains were that, where a good stand had been secured on first planting, an excellent crop of beets was assured. It also offered an excellent opportunity for late plantings in soils well saturated with moisture, which afforded better returns than was formerly thought possible. The conditions were especially adverse in the districts of Chino, Los Alamitos, Oxnard, etc. By the late rains, however, prospects were very much improved.

During the last few years, the northern part of the State, while not affected so much, was cut short of a normal crop, varying from a half up according to the location. This protracted drought has resulted in some permanent good. It has stimulated the employment of irrigating ditches in growing sugar beets.

At Chino over 1,000 acres of beets were grown this year by irrigation, and in some of the districts where sugar beets are grown for the Los Alamitos factory artesian wells were sunk, having a good flow, bringing lands into use that will have a permanent supply of water and making them more reliable resources to the factory.

At Oxnard and Salinas irrigation is becoming a feature of sugar-beet growing. Throughout all the valleys where this crop is grown, irrigation is being more or less resorted to. The limit of assured yearly production in southern California will be very much enhanced by the amount of available lands subject to irrigation.

Fogs, which furnish more or less moisture to the soil, have much to do with the success of a beet crop. Their presence indicates the absence of wind, and prevents heavy evaporation of the stores of moisture in the earth. Sugar beets get along with considerably less moisture, either by rainfall or irrigation, according as these fogs are absent or present. They have been more abundant and have stayed longer than in the past few years.

There has been considerable agitation of the labor question in California during the past year. Negotiations were entered into with a colony of Russians who had settled in Canada. An effort was made to get about 20,000 of these to settle in California and engage in sugar-beet growing. Some of them came. Many of the settlers in these valleys objected to this importation of foreign labor as tending to lower wages. It was contended on the other hand that these settlers are experienced in growing sugar beets. It was claimed that experience had shown that the average American farmer is not prone to enter into the drudgery incident to the production of this crop. This kind of labor in California was formerly the specialty of the Chinaman. He is to-day the market gardener and the farm or ranch laborer whenever his services can be secured. By many he is regarded as the most satisfactory laborer from an agricultural standpoint tried in California. The Chinese are becoming scarce; the operations of the Chinese exclusion law has set a limit. The Chinese labor has been estopped from coming into this country, thus effectually shutting off the supply. The laborers who are here eventually return to their own country, which, along with the natural mortality list, is gradually reducing their number. An attempt has been made to fill the place of the Chinaman by bringing in Japanese. It will take time to determine whether he will be willing and able to do so. Thus California is in a sort of transitional stage so far as labor is concerned.

Hawaii, hitherto more familiar with Japanese labor, is also agitating this problem. Several carloads of the southern negro laborers have recently been taken to Hawaii to work on sugar plantations in order to test their efficiency.

An equilibrium of wage conditions between the Pacific coast and the Hawaiian Islands must eventually be reached. There is a sort of mutual relation existing between these islands and California. The similarity of their conditions and productions seems to demand a close relation of interests. Hawaii is following closely in the footsteps of California in the manner of developing her industrial features. California has to pay about $30 per month for efficient labor in the beet fields. Formerly the wages paid were similar to those which obtained in Hawaii a year or two ago—namely, $12 to $15 per month. Everything is tending in Hawaii to increase the wages, and I believe the time is not far distant when California and Hawaii will both be paying their laborers substantially the same daily or monthly hire.

LOS ALAMITOS.—The Los Alamitos Sugar Company is operating a factory here of 700 tons daily capacity. Owing to the winter drought, which was protracted into the spring, the company and farmers almost despaired of being able to produce a crop of beets. Spring rains very much improved the situation, and the district started in to produce a crop, with a fairly encouraging prospect. About 2,700 acres were planted in beets. The discovery of artesian waters available for use in irrigation was the feature of the year's developments. Several were sunk, and indications point to more in the future. To the extent of the ability to apply irrigation in this way will the factory be benefited and assured of its future crop.

The present winter (1900–1901) conditions have been very favorable for the success of the beets to be raised the coming season. A large rainfall occurred the latter part of November, which was followed with copious rains in December and January. These latter rains came down gradually, covering a period of two or three days each time and recording from 2½ to 3 inches. This starts the crops off with every assurance of success. The land is in fine condition for plowing and seeding, and, with a few showers during the growing season, the farmers of Los Alamitos should be able to realize a splendid crop.

Results at Los Alamitos during the year 1900.

Date of starting the factory	21st of August
Date of closing the same	20th of September
Number of days factory was in operation	31
Number of acres planted to beets	1,500
Number of acres of beets harvested	1,070
Quantity of beets worked ..... tons..	7,500
Average cost of beets per ton	$4.80
Average yield of beets per acre harvested ..... tons..	.7
Average sugar content of beets worked ..... per cent..	17.32
Average coefficient of purity	82.5
Amount of sugar produced ..... tons..	750
Sugar in process ..... do....	60
Total number of employees for the campaign	145

CHINO.—The American Beet Sugar Company is operating a factory here of 1,000 tons daily capacity. Crop conditions at Chino during the past year were quite similar to those described for Los Alamitos. The new feature of the district was the amount of beets grown by irrigation. The American Beet Sugar Company concluded not to operate the factory, but to ship the beets grown here to Oxnard, to be worked up along with beets grown for the Oxnard factory. This company seems to be making every effort to stimulate the farmers in the production of beets. The following item from the Beet Sugar Gazette shows the prices to be paid in the future for beets:

The American Beet Sugar Company of Chino has made a substantial increase in the price of beets for the next campaign. The factory will pay $4.25 per ton for all

beets weighing not to exceed 5 pounds to be raised during the 1901 campaign, regardless of sugar content or purity, and an additional 25 cents per ton will be paid for each per cent above 15. The price prevailing during the season now closing, as in other recent years, was $3.50 per ton for all beets containing 12 per cent sugar, with an additional 25 cents per ton for each per cent above 12. Beets falling below that standard were subject to a discount of 75 cents for each per cent under 12. Thus a beet of 11 per cent sugar brought $2.75, and one of 10 only $2.

Results at Chino during the year 1900.

Number of acres planted to beets	2,39
Number of acres of beets harvested	1,25
Quantity of beets shipped to Oxnard factory ..... tons..	4,14
Average cost of beets per ton	$4.15
Average yield of beets per acre ..... tons..	3.29
Average sugar content of beets worked ..... per cent..	14.5
Average coefficient of purity	78.6
Number of employees kept the year round	15

OXNARD.—The American Beet Sugar Company is operating a factory here of 2,000 tons daily capacity. The same winter drought described for Los Alamitos and Chino prevailed here, but the later spring rains did much to recoup the district. The record of the year was not a very high tonnage per acre, but the percentage of sugar in the beets grown was quite remarkable, and this did much to make up the loss to the farmer in the gross weight of beets. Beet diseases were quite noticeable throughout the district. The main feature of the year's work was the establishment by the company of large feeding yards adjacent to the factory. These yards were stocked with cattle and fed from the pulp produced by it. The factory began slicing August 15. Owing to the limited supply of beets it was decided to use but half of the capacity for working them. In working on this half-capacity run the factory several times reached 1,100 tons of beets daily.

Results at Oxnard during the year 1900.

Date of commencing factory operations	15th of August
Date of closing same	18th of October
Number of days operating	60
Number of acres planted to beets	7,184
Number of acres of beets harvested	6,238
Quantity of beets worked ..... tons..	66,886
Average cost of beets per ton	$5.01
Average yield of beets per acre ..... tons..	10[illegible]
Average sugar content of beets worked ..... per cent..	1[illegible]
Average coefficient of purity	81
Amount of sugar produced[1] ..... tons..	9,696.45
Sugar in process ..... do...	348.9
Average number of employees for the campaign	58[illegible]

[1] Including product from purchased molasses.

SALINAS.—The Spreckles Sugar Company is operating a factory here of 3,000 tons daily capacity. The Salinas district, probably more than any other, had to contend with the diseases affecting the sugar-beet crop during the past year. The consequences of the root blight or rot were far-reaching, both as to its present effects and the alarm it has aroused as to consequences in the future. The factory requires a large tonnage of sugar beets daily for its work. It has the largest working capacity of any factory in the world, namely 3,000 tons.

Irrigation was tried quite extensively in different sections during the past year with very favorable results. With the present favorable crop prospects and no recurrence of the beet disease, this district will have a large area in beets for 1901. After the next crop it will be possible to know something of the effect which a diseased crop will have on the succeeding crop of beets on the same land.

SANTA MARIA.—The Union Sugar Company is operating a factory here of 500 tons daily capacity. The climatic conditions affecting the beets grown in this section were quite similar to those described for other factories in southern California. The acreage was not nearly so large or the tonnage so good as had been anticipated. The factory began its campaign about September 10 and closed about November 10.

The company is taking the same steps to solve the question of the future supply of beets as are being taken by several other companies in California. It is getting control of large tracts of land, which it leases to growers. The factory was originally designed with a view of increasing the working capacity to 1,000 tons. Up to date it seems able only to supply itself with about 350 tons daily for short campaigns. Plans were matured, however, for securing a supply of beets in the future and running the factory at the 1,000-ton capacity for a longer campaign.

CROCKETT.—The California and Hawaiian Sugar Refining Company is operating a factory here of 1,000 tons daily capacity. This factory is designed to refine sugar in addition to manufacturing sugar from beets. The supply of beets this year was not very large. It was estimated to be about 10,000 tons, which gave it but a short campaign.

Results at Crockett during the year 1900.

Date of commencement of campaign		1st of August
Date of closing same		15th of October
Number of days factory was in actual operation		15
Number of acres planted to beets		5,800
Number of acres of beets harvested		2,500
Quantity of beets worked	tons	8,704.56
Average yield of beets per acre	do	3.5
Average sugar content of beets worked	per cent	19.39
Average coefficient of purity		81.6
Quantity of sugar produced	tons	1,328.7
Number of employees during the campaign		125

ALVARADO AND WATSONVILLE.—At Alvarado, Cal., the Alameda Sugar Company is operating a factory of 800 tons daily capacity, and at Watsonville the Western Beet Sugar Company is operating a factory of 1,000 tons daily capacity.

These two concerns are the oldest and most successfully operated sugar factories in the State. It has been impossible to get specific details with reference to the history of last year's work. The factory at Watsonville sent its beets in 1899 to Salinas to be worked up. It belongs to the same company as the Salinas factory.

It is understood that in 1900 fairly good crops were raised for both the Alvarado and the Watsonville factories. And it has further been announced on good authority that the Watsonville factory worked up its own supply of beets grown the past season. The bountiful supply of rainfall and snow during the winter has assured an abundant supply of beets for operating these factories in 1901.

IN COLORADO.

Colorado is a recent acquisition to the list of States manufacturing sugar. It has one factory that has operated for two years, and two others that have worked through one campaign. These factories are located at Grand Junction, Rocky Ford, and Sugar City. The State is to have one more factory (possibly two) to engage in the manufacture of sugar in 1901. The special feature of Colorado's sugar production is that the beets are grown almost entirely by irrigation. It has been shown so far as the factories already installed in the State have operated that there are many advantages in the peculiar conditions that prevail, and that it has large tracts of land quite similar to the districts now being tested by these sugar factories. It is very probable that with their success many more will be installed in the State. The beets grown during the past year were very high in their sugar content and purity, averaging throughout the campaign in one instance over 17 per cent sugar. It is the peculiar advantage of these valleys that rain rarely falls after a certain time in the growing season of the beets. After the crop has been produced by irrigation it can be allowed to remain in the soil and ripen unaffected by rain. This gives a better opportunity to control the size and the ripening of the beets and makes it possible to force an early harvest. It also avoids more or less the necessity of siloing or harvesting until beets can be delivered, except where it becomes necessary to avoid freezing.

One of the experiments tried in Colorado with favorable results was the growing of sugar beets as the first crop on new land. The conditions of farming surrounding the three factories already installed are very much the same. Fruit, vegetables, and alfalfa have been the principal crops previous to the introduction of sugar beets. This new crop adds value to the valleys in that it increases their crop resources and offers a better opportunity for a system of rotation.

GRAND JUNCTION.—The Colorado Sugar Manufacturing Company of his place has installed a factory of 350 tons capacity. Grand Junction is situated in a fruit district in the Grand River Valley. This section has established a reputation for producing a high quality of the different deciduous fruits. During the two seasons that beets have been grown for the factory it has been demonstrated that the soil will produce beets of high quality. This company has done the pioneer work of sugar-beet growing for the State; it has had to study out the methods of successfully growing this crop under the peculiar conditions that exist; in doing this it has met many adverse influences and shouldered the results of much experience. New factories starting in the State can naturally take advantage of facts that have been already determined, and it is probable that no other factory will have to contend with as much as this one did in the beginning. The results of the past year are a great improvement over the one previous. It was found almost impossible from the beginning to secure sufficient previously cultivated ground upon which to grow the crop of beets, most of the lands in the district that have been under cultivation for any length of time having been devoted to growing alfalfa and other well-known crops, or they had been planted in orchards, upon the profitableness of which the people of the district had learned to rely.

For the first year much of the crop of sugar beets was grown between the rows of these young fruit trees, and the double purpose was served of growing the crop and cultivating the young trees. This was found a process not adapted to producing the best beets. In many other instances the attempt was made to reclaim new land by using sugar beets as a first crop. The application of water by irrigation to this new crop was not well understood at this time. The first year there was quite a serious attack by insects. The two years' experience that the factory has passed through will greatly benefit the growers of sugar-beets for this factory and others that will be established in the State from time to time.

The factory started up about September 20, 1900, working its brown sugars left over from the previous campaign, and began slicing beets about October 1. The beets grown in the district were quite high in sugar content and purity, the average in sugar being over 16 per cent, with a purity coefficient of about 83. Farmers received $4.25 per ton for their beets running from 12 to 15 per cent sugar, and 25 cents additional for each additional per cent or fraction thereof. We clip from the Sugar Beet a new schedule of prices offered by this company, as follows:

	Per ton.
Beets with 22 per cent sugar	$7.58½
Beets with 21 per cent sugar	7.25
Beets with 20 per cent sugar	6.91½
Beets with 19 per cent sugar	6.58½
Beets with 18 per cent sugar	6.25

	Per ton.
Beets with 17 per cent sugar	$5.91¼
Beets with 16 per cent sugar	5.58¼
Beets with 15 per cent sugar	5.25
Beets with 14 per cent sugar	4.91¼
Beets with 13 per cent sugar	4.58¼
Beets with 12 per cent sugar	4.25

SUGAR CITY.—The National Sugar Company is operating a factory at this place of 500 tons daily capacity. The factory began its campaign November 15, 1900. This was its first campaign, and the showing made is a wonderful proof of the resourcefulness of the Arkansas Valley for growing sugar beets. Many of the fields were planted on new and untried land. The results were a very high sugar content and a fairly good tonnage per acre.

ROCKYFORD.—The American Beet Sugar Company is operating a factory at this place having 1,000 tons daily capacity. It began slicing beets October 11, 1900. It is probable that the results obtained by the farming community growing beets for this factory are more typical of what can be accomplished in the Arkansas Valley than those given for Sugar City (which is near), from the fact that conditions are more settled and favorable for producing beets. It is certain that no other district in the United States has ever attained such high success in growing beets for the first time as this one has. In fact the results would rival the best attained by any other factory district in its most favored years. The sugar content of the beets was very high and the tonnage grown per acre was everything that could be desired.

The high content of the sugar made the growing of the crop quite profitable to the farmers, since beets showing this high percentage are worth $5 per ton. There is nothing in the system of agriculture prevailing in this district necessitating an unusual expense in producing the crop; and yet it seems possible from the present year's results that the district will be able to average as high as 15 tons during ordinary years. With this high quality of the beet, the farmer will receive $5 per ton for his beets, giving, according to this estimate, about $75 per acre, a net profit of at least $45 per acre. These results probably reach the high-water mark of favorable showing that this industry has made in this country up to date.

Results at Rockyford during the year 1900.

Date of commencing factory operations	14th of October
Date of closing same	9th of December
Number of days operating	60
Number of acres planted to beets	5,635
Number of acres of beets harvested	4,530
Quantity of beets worked ..... tons..	41,656
Average cost of beets per ton	$4.76
Average yield of beets per acre ..... tons..	9.77

verage sugar content of beets worked	per cent..	16.41
verage coefficient of purity		83.6
mount of sugar produced	tons..	4,491.75
ugar in process	do...	106
lumber of employees for the campaign		425

IN ILLINOIS.

PEKIN.—The Illinois Sugar Refining Company is operating a factory at this place, having a working capacity of 700 tons. This factory has gone through two campaigns, both of which can be pronounced quite successful, considering that they are the opening or experimental years of the factory. This State started in the manufacture of sugar from sugar beets over one-third of a century ago. A factory was built at Champaign. After leading a precarious existence of two or three years it was finally taken down and removed to some other locality. It seemed that the time was not ripe for introducing the sugar industry at that time. The perfection of the process and the conditions of manufacture that obtained at that time in manufacturing sugar from beets were not such as to combine with the system of agriculture then in vogue in Illinois. The system of farming was too crude to take up with a branch of agriculture that was so intensive. Wild land could be had farther west for a merely nominal sum; the public domain was open for free grazing. Only such things were produced as could be raised with the least effort. Farming meant the production of hogs, cattle, corn, wheat, and oats. Now the situation is changed. The range has gone farther west; the land has become valuable, and it must be made to produce those things that will give the greatest returns from small acreage. The farmer is the copartner with the manufacturer of prepared meats, poultry, butter, cheese, and canned fruits and vegetables. As a feature of this era of intensive farming, comes the sugar industry. The same number of acres provides employment for many times the same amount of labor. The history of civilization is repeated. As a community becomes older it becomes more populous and more intensive in its system of industries; it must provide for more and more employment and at the same time adjust itself to a system of production that can compensate this extra labor and give a fair return to the producer.

Illinois, in commencing her second attempt at installing the sugar industry, has reached this period. She has one factory that is demonstrating its usefulness to the agricultural and commercial classes of the State. She has many more localities that are equally fitted for installing this industry, localities that have been thoroughly tested by the State agricultural experiment station and local organizations. Many of these places are on the eve of effecting organization, and capitalizing and constructing factories. It can be but a little while until Illinois will be taking advantage of these many opportunities that

exist in the State and, along with the State o Michigan, will enter the field in earnest, manufacturing sugar and supplying the great demand for this product. There is abundant capital in the State seeking employment to build the factories when it becomes apparent that there is profit in doing so. An early day will see the installation of many of these plants, the smoke from whose stacks will indicate that the coal of the State is being consumed in working up a product from her own farms, giving employment to home labor and yielding a product for home consumption.

The factory at Pekin is working the beets from about 5,000 acres, and is distributing to the farmers over $200,000 annually. The year 1900 has been quite dry and the crop has not been all that could be desired; yet there has been enough even in the two unfavorable years to convince the farmers of the great advantage of living in the vicinity of a sugar factory and possessing the privilege of producing beets for the same.

IN MICHIGAN.

The showing of the sugar industry in Michigan has very much improved through the results of the past season. Climatic conditions throughout the State have been very good. Farmers have gone into the work of this year with considerable more intelligent effort. The results are that all the factories have been working on a very much increased supply of beets which show a great improvement in their sugar content and purity. Where the campaign of 1899 closed with almost complete discouragement, now everyone is feeling highly pleased with the showing made. The work thrown on this State in one season of installing nine sugar factories and growing the beets for them was a tremendous strain on its resources. The farmers were entirely unacquainted with the subject. They did not know how to take advantage of favorable conditions or to ward off the effects of unfavorable ones.

In 1899 the parties connected with the factories were too much interested in building them, in installing the machinery, and getting everything in readiness to give any attention to the growing of the beets. The feeling seemed to prevail among the agricultural classes of the State that sugar beets as a crop would succeed on any kind of land. In many instances lands were planted in sugar beets that had been a failure for some years in producing any other kind of crop. The most valuable result of that year's work was the accumulation of experience.

Farmers were prepared to plant their crop of sugar beets for 1900 with considerable more wisdom. The factories installed regular agriculturists to supervise and aid the farmers and to bring the two classes into closer harmony and union of interests. The conditions for growing sugar beets have been excellent. The results have been very favorable and encouraging. With the experience of the last two years, it can be safely counted that Michigan has launched in a career of suc-

essful sugar production. It has more factories than any other State. The indications are that more new factories will be started in Michigan han in any other State in the near future. From the Sugar Beet is clipped the following condensed statement showing the results in Michgan during the past year:

As the campaign in Michigan is drawing to a close, an estimate may be made of the total output of all the factories that were in operation. This estimate would put the figures at 50,000,000 pounds, or 25,000 tons of sugar turned out. The farmers of Michigan have raised 250,000 tons of beets, for which they have received, in round numbers, $1,000,000.

The companies whose factories have been in operation this campaign and the approximate amounts of sugar turned out by each are as follows:

Estimated product of sugar by Michigan factories for 1900.

	Pounds.
Michigan Sugar Company, Bay City	6,670,000
Bay City Sugar Company	12,000,000
West Bay City Sugar Company	5,700,000
Wolverine Sugar Company, of Benton Harbor	1,031,265
Alma Beet Sugar Company	7,000,000
Holland Sugar Company	9,000,000
Kalamazoo Beet Sugar Company	1,500,000
Peninsular Sugar Refining Company	7,000,000

This gives a total of approximately 50,000,000 pounds, to which must be added the output of the Marine Sugar Company, of Marine City, Mich., which began its campaign December 18 and has a working capacity of 300 tons of beets per day.

It will be interesting, for the purposes of comparison with the above output during the past year, to examine the results at the same factories for the previous year. This will show the improvement that has taken place in Michigan after a year's experience and during a season that was more nearly normal in its crop conditions. The following figures are taken from the fifty-eighth annual report of the commissioner of the land office of the State of Michigan. They are compiled from the returns made from the factories to this office on their output and upon which they based their claims for the bounty of 1 cent per pound under the then existing law of the State:

Product of sugar by Michigan factories for 1899.

	Pounds.
Michigan Sugar Company	7,415,233
Bay City Sugar Company	6,942,132
West Bay City Sugar Company	2,095,808
Alma Sugar Company	3,359,368
Kalamazoo Sugar Company	1,440,598
Wolverine Sugar Company	1,701,082
Holland Sugar Company	2,461,919
Detroit Sugar Company	3,669,839
Peninsular Sugar Refining Company	4,064,894
Total	33,150,873

Total tons, 16,575.

The conditions in the State were so very similar throughout the various sections where factories are located that it will be unnecessary to describe them in connection with any particular factory. The supply of beets in each case was highly satisfactory and their quality was good.

BAY CITY.—This factory, built by the Michigan Sugar Company, was the first started in the State, consequently the campaign of 1900 was its third. The factory started up on the 4th day of October. It has put in operation the osmose system of treating molasses; in fact, it has made quite a number of improvements since the first year. Statistics of the year's work are not yet fully completed, but every indication points to the fact that the farmers have very much increased their tonnage per acre, and that sugar-beet growing has been a very profitable enterprise for the season. In quality, the beets are higher than any grown before.

The Bay City Sugar Company has constructed a factory at this place side by side with the one mentioned above. It has a daily capacity for working 600 tons of beets. Its supply of beets was very much increased and improved in quality over that for the previous campaign.

WEST BAY CITY.—The West Bay City Sugar Company is operating a factory at this place having a daily capacity of 500 tons. This factory was completed late in 1899, and had a limited supply of beets for the first year's campaign. In 1900 the supply of beets was a great deal more abundant, and the factory was able to test its resources more effectually.

ALMA.—The Alma Sugar Company is operating a factory at this place having a capacity of 500 tons daily. It secured an abundant supply of good beets, and started early on its contracts with the farmers for the supply for next campaign. The results of this year's work have convinced the farmers that sugar beets are a profitable crop, and they are showing their appreciation of this fact by readily entering into contracts with the factory for furnishing its next year's supply.

Results at Alma for the year 1900.

Date of commencing factory operations		15th of October
Date of closing same		24th of December
Number of days actually in operation		64
Number of acres planted to beets		3,200
Number of acres of beets harvested		3,200
Quantity of beets worked	tons	32,800
Average cost of beets per ton		$5.33
Average yield of beets per acre	tons	10.25
Average sugar content of beets worked	per cent	14.5
Average coefficient of purity		83.47
Amount of sugar produced	tons	3,500
Average number of employees for the campaign		275

KALAMAZOO.—The Kalamazoo Beet Sugar Company is operating a factory at this place having a capacity of 500 tons daily. It began its campaign October 9, 1900, with a large crop of beets ready. The yield per acre was about half as large again as that of last year, and the farmers demonstrated that they could reduce the cost of production for the second year's crop almost 50 per cent. They also received considerable advance over the price of last year's beets.

BENTON HARBOR.—The Wolverine Sugar Company is operating a factory at this place having a daily capacity of 350 tons. It began its campaign October 25, 1900. The supply of beets for the factory was very much increased and the quality of the same greatly improved. The supply for the campaign was very much less, however, than it should have been. The factory closed down December 19 after a run of twenty-seven days, slicing 7,000 tons of beets.

The company will make an energetic effort to better the situation for next campaign. It is offering 50 cents per ton advance over the previous price. The factory has had more or less trouble in securing a supply of beets during the past two years. Farmers have not taken hold of the proposition as actively as in other places in Michigan. It is confidently expected that the advance in price and the extra effort the factory is making to get a supply will put it in position to run a full campaign next year as well as a successful one.

HOLLAND.—The Holland Sugar Company is operating a factory at this place having a daily capacity of 350 tons of beets. This is one of the places that was especially mentioned last year as growing beets upon inferior or worn-out soils to a considerable extent. In making their plans for the season of 1900 the sugar-beet growers made better selections. The average tonnage of the beets produced in this section shows that sugar-beet growing is profitable. In cases where the best lands were selected and careful attention was given to the cultivation of the crop, results were secured that can not be excelled or equaled with any other crop on the farm.

The factory worked up about 19,000 tons of beets, and paid the farmers therefor about $85,000. The acreage planted was slightly over half what it was the previous year, but the supply of beets was about 500 tons greater. The results were so favorable to those participating in growing the beets that the farmers are anxious to renew the experiment and are readily making contracts for next year's supply.

Results at Holland during the year 1900.

Date of commencing factory operations	15th of October
Date of closing same	24th of December
Number of days operating	62
Number of acres planted to beets	2,000
Number of acres of beets harvested	1,800
Quantity of beets worked ..... tons..	17,242

Average cost of beets per ton	$4.9
Average yield of beets per acre.....tons..	9.3
Average sugar content of beets worked .....per cent.	12.5
Average coefficient of purity	82.6
Amount of sugar produced .....tons..	1,673.7
Sugar in process .....do...	75
Number of employees for the campaign	120

ROCHESTER.—The Detroit Sugar Company has constructed a factory at this place having a daily capacity of 500 tons. On October 19, 1900, it began its second campaign. The beets grown in the vicinity showed a considerable increase in the tonnage per acre and sugar content. The factory closed December 20, being in operation about two months.

The acreage was considerably less than that of the year previous, but the output of sugar was a little greater. It was a favorable year for growing the beets, and the results were quite encouraging. The farmers are entering readily into contracts, and the supply for next campaign will be considerably increased.

CARO.—The Peninsular Sugar Refining Company is operating a factory at this place having a daily capacity of 600 tons of beets. It started on its campaign October 18, 1900. It is using the Steffin process in securing the sugar from the molasses. The company has been at considerable expense revising and improving its factory after the first year's run. The results of growing the beets in this vicinity have been very encouraging. The average tonnage is high, the sugar quality of the beet is good. The campaign was closed about December 25, so far as working beets was concerned. About 25,000 tons of beets were worked during the run, and the farmers in that section received about $110,000 for the same.

The experience of this factory during its first year's run, so far as the amount and quality of the beets were concerned, was much more encouraging than that of any other factory in the State. This was on account of the excellent and intelligent supervision on the part of the agriculturist of the factory. The results for 1900 have shown quite an improvement over those for 1899, and the two years have given the farmers every indication that the factory is in position to aid them materially and profitably. The main drawback has been in the working of the factory itself. It has been very carefully revised and improved and it is one of the most successful plants in the State.

MARINE CITY.—The Marine Sugar Company established a factory at this place with a working capacity of 350 tons of beets daily, making its first run the past season (1900). The farming community furnishing the beets for this factory had the benefit of the experience of the State in growing sugar beets for the other factories the year before. It is the latest factory constructed in the State. For the first year's experience the beets were exceptionally good in quality and quantity, and the farmers were highly encouraged with the results of the crop.

Some trouble was experienced in a few fields' being overrun with the army worm, which came onto the beets from other adjoining crops. No material damage was done, however. The farmers learned that the beet crop is subject to attack by this pest, studied methods for warding it off, and will be prepared for such emergencies in the future. Along with the other beet-growing districts, this one enjoyed the normal conditions for sugar-beet growing that prevailed throughout the State, and the farmers are better prepared, and more inclined, to engage in sugar-beet growing in the future.

IN MINNESOTA.

ST. LOUIS PARK.—The Minnesota Sugar Company is operating a factory at this place of 400 tons daily capacity. Minnesota experienced an unprecedented drought during the early part of the summer. At a time when the beets needed rain most for germination and for starting them on a vigorous growth it was very dry. In many fields the beets failed to come up, or did not come up in sufficient numbers to insure a stand. Reseeding was resorted to in many cases, and with quite good results. These second plantings were necessarily late, but not infrequently they produced a good supply of beets of good quality.

As a rule, where the beets did not materialize by the middle of June, the farmers plowed up the ground and put it in something else. There is this encouragement to be derived from the situation in Minnesota, however: The main crops upon which the State relied for years were a partial failure. This was especially true of the northern half of the State. Flax fared considerably better. Comparing the beet crop with these, much can be claimed for its success, as the yield was very much better. In fact, in most of the fields the sugar beets were good where a stand was secured in the spring, and the farmers continued to cultivate the crop. During the season the beets were not attacked by any diseases or insects.

The campaign opened up about October 6 and closed December 2, lasting fifty-eight days, about half the time that it should have operated under normal conditions.

Results at St. Louis Park during the year 1900.

Date of commencing factory operations	6th of October
Date of closing same	2d of December
Number of days operating	58
Number of acres planted to beets	3,000
Number of acres of beets harvested	1,900
Quantity of beets worked ..... tons..	18,500
Average cost of beets per ton	$4.85
Average yield of beets per acre ..... tons..	10
Average sugar content of beets worked ..... per cent..	11
Average coefficient of purity	80
Amount of sugar produced ..... tons..	1,328.2
Sugar in process ..... do....	130
Number of employees for the campaign	250

IN NEBRASKA.

The general conditions for growing sugar beets in the State were not very favorable during the past year. In the early part of the summer indications were that a good crop would be produced, and the sugar interests were looking forward to a successful campaign in sugar making.

In the latter part of July there was an intensely hot spell that lasted up to the second week in August. After this the beets were injuriously affected in several ways, which resulted in material loss to the farmers growing them. In some cases the beets would wither up and become woody, also quite flexible and leathery; in other cases a rot would begin with the taproot following it up until the entire beet was consumed and stood a rotten mass in the ground; in still others the rot would begin at the crown and consume the beet from the top downward.

This period of misfortune was followed in the fall by one of excessive and prolonged rainfall which interfered with the ripening of the beets. All these tendencies materially affected the sugar content and the tonnage per acre. So it can be said that the sugar-beet crop in Nebraska during the past year was far from a normal one.

AMES.—The Standard Beet Sugar Company has a factory at this place of 500 tons daily capacity. The sugar beets are grown here on the rich, heavy bottom lands, while at Grand Island and Norfolk the beets are grown more on upland or sandy soils.

In 1900 the Standard Cattle Company of this place alone grew 2,000 acres of the beets, a little more than one-third of the factory's entire supply of beets.

This is the second year's run for the factory and conditions have not been normal during either year. At seeding time it was quite dry and unfavorable to germination. This was followed in the latter part of July and August with intensely hot weather. The latter part of the season during September and October when the beets should have been ripening, there was a heavy rainfall and a prolonged wet season. The beets were slow to ripen, which retarded the commencement of the campaign. The excessive wet kept the beets growing and was probably beneficial in causing a larger tonnage than might have been otherwise.

Following the hot spell in the summer the beets in this section were very badly afflicted with what has been commonly termed "leaf blight," "leaf spot," and "root blight." It seemed that all of these troubles were more or less present. Indications were that a single beet would be affected by all three of these. I examined many fields during the latter part of September and noted the prevalence of these diseases. Reports from there afterwards seemed to indicate that the growing spell engendered by the late rains had a tendency to correct some of

the bad effects of the preceding unfavorable conditions, and that beets only slightly affected regained more or less their normal condition.

Under the head of "Insects and diseases" (p. 68) is given a review of these troubles, made by a competent person on the ground during their prevalence.

Results at Ames during the year 1900.

Date of commencing factory operations		6th of October
Date of closing same		10th of January
Number of days operating		102
Number of acres planted to beets		4,267
Number of acres of beets harvested		4,055
Quantity of beets worked	tons	36,440
Average cost of beets per ton		$3.90
Average yield of beets per acre	tons	9
Average sugar content of beets worked	per cent	9.59
Average coefficient of purity		71.91
Amount of sugar produced	tons	2,459
Sugar in process	do	199.2
Number of employees during the campaign		265

GRAND ISLAND.—The American Beet Sugar Company has been operating a factory at this place for several years. This factory has a capacity of 350 tons per day. The season started in quite favorable, and in June the indications were that a good crop would be secured. In the latter part of July and early August an unprecedented hot spell prevailed. This was followed by the sugar-beet diseases that have been in evidence in several sections. They were especially severe in the beet fields surrounding Grand Island.

I went through a great many fields during the latter part of September. I estimated that the loss from beets already dead was over half the crop, and the rest of the beets were more or less affected. The factory at this place did not open up during the campaign, but shipped its beets to Norfolk, where the company has another factory.

Results at Grand Island during the year 1900.

Number of acres planted to beets		2,409
Number of acres of beets harvested		1,870
Quantity of beets worked (shipped to Norfolk)	tons	12,857
Average cost of beets per ton		$3.68
Average yield of beets per acre	tons	6.82
Average sugar content of beets worked	per cent	12.4
Average coefficient of purity		79

NORFOLK.—The American Beet Sugar Company has a factory here of 350 tons daily capacity. The climatic conditions were very similar to those described for Grand Island and Ames. The beets were attacked by disease here, but the bad effects were not so pronounced as at Grand Island, probably owing to the fact that the soils are much better able to withstand the effects of drought.

The factory worked up the crop of beets grown at Grand Island along with the beets grown for this factory. It began operations October 8 and closed December 20, having a campaign of seventy days. In the beginning the beets showed a low percentage of sugar. It seems the factory owners realized that some concessions must be made to keep up the interest of the farmers, as they were likely to be discouraged with the results of the crop. So the following order was issued:

Owing to the fact that in some localities the beets are testing considerably below standard, which is undoubtedly due to the continued heavy rainfall, we have decided to vary from the established contract prices as follows:

The purity will not be considered in determining the price, it being based on sugar content entirely. The 15 per cent deduction for each per cent or fraction thereof of purity will therefore not be made. This means that a beet testing 12 per cent sugar with a purity below 78 per cent will still be a $4 beet, and likewise on lower grades the purity will not affect the price as determined by the sugar.

Beets testing below 10 per cent sugar and 73 per cent purity will be received if the sugar content is not so low that it is absolutely impossible to use them in the factory. Appreciating the fact that, at a price of less than $3 per ton, the returns would be insufficient to cover the cost of production, that shall be the minimum price, and any beets that it will be possible to work will be received at that figure. These changes, of course, favor the grower and are made because the season has been very unfavorable so far as ripening the crop is concerned.

Results at Norfolk during the year 1900.

Date of commencing factory operations		9th of October
Date of closing same		17th of December
Number of days factory was in operation		68
Number of acres planted to beets		1,853
Number of acres of beets harvested		1,800
Quantity of beets worked[1]	tons	26,038.9
Average cost of beets per ton		$4.88
Average yield of beets per acre	tons	8
Average sugar content of beets worked	per cent	11.7
Average coefficient of purity		77.9
Amount of sugar produced	tons	2,314.45
Sugar in process	do	101.4
Number of employees during the campaign		215

IN NEW MEXICO.

CARLSBAD.—The Pecos Valley Beet Sugar Company has been operating a factory here having a capacity of 200 tons daily. The beets grown for the factory receive their moisture entirely through irrigation. The water is taken from the Pecos River, a branch of the Rio Grande. The factory has been in operation for several years.

One of the difficulties of this section is that it has not been able to grow a sufficient variety of field crops in order to carry out a practical rotation. Alfalfa is the principal crop outside of sugar beets. The section has succeeded well in vegetables and fruits, especially grapes

[1] Including beets shipped from Grand Island.

and deciduous fruits; but fruit is not a product that can be practically brought into rotation with field crops.

The fields of sugar beets during the past two or three seasons have been very much affected with what is termed "black root rot." The effect of this was quite discouraging to the farmers and factory. After mature deliberation on the subject it was finally considered best to discontinue the growing of sugar beets for a while and plant the lands in something else. It was thought by some also that the trouble with the beets was from lack of nitrogen in the soil. It was therefore considered advisable to reinvigorate it by growing one of the legumes, and the land was largely sown to alfalfa, it having been previously demonstrated that this is an available crop in that section.

IN NEW YORK.

The development of the agricultural industries of the West has produced a competition from which the farmers of the East have suffered. The farmers of the West engaged in the production of meats, butter, eggs, and poultry; and they were able to place these products in the Eastern markets at a lower figure than that at which the New York farmer with his high-priced land, expensive labor, and expensive tillage, could afford to produce them. This forced the Eastern farmer to study the intensive side of agricultural production. Canneries of all kinds were introduced, also butter and cheese factories. The production of sugar appealed to this section as an industry peculiarly fitted to its conditions.

ROME.—The First New York Sugar Company operates a factory here of 200 tons daily capacity. This factory started up about three years ago. It is one of foreign make and small capacity. It was originally designed to work about 200 tons of beets per day but never came up to that record in actual work. It has since been overhauled and very much improved.

For some reason the farmers did not give the cultivation of sugar beets sufficient attention to become accustomed to the benefits of growing the crop. The factory made a mistake the first year in the quality of its seed and the beets were low in sugar and purity. This had a disheartening tendency and it seems that it has been impossible to work up enough enthusiasm among the farmers to keep the factory supplied with beets for any length of time. The results are that the industry never has had a good test in the community. It is reported that there is a plan on foot to reorganize this company and start the factory on a career of usefulness in the near future.

BINGHAMTON.—The Binghamton Beet Sugar Company is operating a factory here of 350 tons daily capacity. This factory started in with every indication of success. The farmers seemed determined to give sugar-beet raising a thorough test. The early part of the season

The factory worked up the crop of beets grown at Grand Island along with the beets grown for this factory. It began operations October 8 and closed December 20, having a campaign of seventy days. In the beginning the beets showed a low percentage of sugar. It seems the factory owners realized that some concessions must be made to keep up the interest of the farmers, as they were likely to be discouraged with the results of the crop. So the following order was issued:

Owing to the fact that in some localities the beets are testing considerably below standard, which is undoubtedly due to the continued heavy rainfall, we have decided to vary from the established contract prices as follows:

The purity will not be considered in determining the price, it being based on sugar content entirely. The 15 per cent deduction for each per cent or fraction thereof of purity will therefore not be made. This means that a beet testing 12 per cent sugar with a purity below 78 per cent will still be a $4 beet, and likewise on lower grades the purity will not affect the price as determined by the sugar.

Beets testing below 10 per cent sugar and 73 per cent purity will be received if the sugar content is not so low that it is absolutely impossible to use them in the factory. Appreciating the fact that, at a price of less than $3 per ton, the returns would be insufficient to cover the cost of production, that shall be the minimum price, and any beets that it will be possible to work will be received at that figure. These changes, of course, favor the grower and are made because the season has been very unfavorable so far as ripening the crop is concerned.

Results at Norfolk during the year 1900.

Date of commencing factory operations		9th of October
Date of closing same		17th of December
Number of days factory was in operation		68
Number of acres planted to beets		1,853
Number of acres of beets harvested		1,800
Quantity of beets worked[1]	tons	26,038.9
Average cost of beets per ton		$4.38
Average yield of beets per acre	tons	8
Average sugar content of beets worked	per cent	11.7
Average coefficient of purity		77.9
Amount of sugar produced	tons	2,314.45
Sugar in process	do	101.4
Number of employees during the campaign		215

IN NEW MEXICO.

CARLSBAD.—The Pecos Valley Beet Sugar Company has been operating a factory here having a capacity of 200 tons daily. The beets grown for the factory receive their moisture entirely through irrigation. The water is taken from the Pecos River, a branch of the Rio Grande. The factory has been in operation for several years.

One of the difficulties of this section is that it has not been able to grow a sufficient variety of field crops in order to carry out a practical rotation. Alfalfa is the principal crop outside of sugar beets. The section has succeeded well in vegetables and fruits, especially grapes

[1] Including beets shipped from Grand Island.

and deciduous fruits; but fruit is not a product that can be practically brought into rotation with field crops.

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of 1900 was quite dry. This was followed by good rains in June, and the season on the whole was fairly favorable for the production of a crop. The supply of beets for the factory was increased about half over that of the previous year.

Experience is telling in favor of the production of sugar beets in the farming districts available to this factory. They are grown in an area surrounding the factory having a radius of about 75 miles. The larger farmers, or those putting in the largest acreage of beets, have had much the best success in raising the crop, showing that responsibility is a feature in growing this crop. The small farmers who grew them as a sort of experiment or an incidental crop have not done so well. But it is upon the showing made by the farmers who have grown them as a crop and expended sufficient labor and money to produce them that the results must be judged. Fortunately no sugar-beet disease worth mentioning appeared in this district, and insects were no more active than is usual with growing crops.

The factory is able to dispose of its pulp as fast as it is produced at 50 cents per ton; it is taken generally by farmers returning home after delivering beets; but considerable pulp is shipped out in carload lots. On guaranteed contracts the factory can realize $1 per ton. It seems evident that it is only a question of a short time when this factory will be able to dispose of all its pulp at this figure.

The factory began operations October 8 and closed about the middle of January.

Results at Binghamton during the year 1900.

Date of commencement of factory operations	8th of October
Number of acres planted to beets	2,200
Number of acres of beets harvested	1,900
Quantity of beets worked ..... tons	19,000
Average cost of beets per ton	$5.00
Average yield of beets per acre ..... tons	10
Average sugar content of beets worked ..... per cent	13
Average coefficient of purity	81
Amount of sugar produced ..... tons	1,160
Sugar in process ..... do	90
Number of employees during the campaign	120

LYONS.—The Empire State Sugar Company is operating a factory here of 600 tons daily capacity. Last year (1900) was its first campaign. It made contracts with the farmers for about 5,000 acres of beets. Several hundred acres had been grown in the county during previous years for the factories at Rome and Binghamton. The season was very good, and the beets produced were considerably above the average tonnage of localities growing beets for the first time. The average sugar content and purity ranged above the requirement for factory purposes. The experience this year indicates that everything is favorable, and with the knowledge already derived, the factory

will be able to sustain itself and mark out a career of usefulness in the sugar industry.

Results at Lyons during the year 1900.

Date of commencement of factory operations	16th of October
Date of closing same	25th of January
Number of days operating	101
Number of acres of beets planted	4,300
Number of acres harvested	4,000
Quantity of beets worked	tons.. 35,000
Average cost of beets per ton	$5.00
Average yield of beets per acre	tons.. 8.75
Average sugar content of beets worked	per cent.. 12.8
Average coefficient of purity	81.9
Amount of sugar produced	tons.. 2,500
Number of employees during the campaign	150

IN OHIO.

FREMONT.—The Continental Sugar Company is operating a factory here of 350 tons daily capacity. This section had grown beets more or less in a practical way during the season of 1899. The season of 1900, or the growing part of it, was very favorable to the growth of this crop. In making the selection of land upon which to plant the beets, the farmers in many instances made the mistake that characterized Michigan's first attempt. The farming section is an old one and the lands have been in cultivation a good while. Many of them are becoming quite exhausted of their native fertility. The impression prevailed that sugar beets were a crop that would thrive on these exhausted lands. The error was discovered, however, by the year's experience, and the section will show much better results in the future. Better selections of land will be made next year.

A fair tonnage was produced, considerably better than that shown in Michigan's first attempt, owing to the fact that climatic conditions were better and farmers knew more about the crop than did those of Michigan during their first attempt. The company really experienced more difficulty than the farmers. The fall rains were excessive. They continued to a later period than usual. The beets were kept growing and not allowed to ripen. This helped the tonnage of the farmers, but lowered the sugar content of the beets. The results were sufficient to encourage the farmers to continue the enterprise, and the factory will undoubtedly have a sufficient supply for its next campaign. With better climatic conditions and with the experience of last year's effort, beets will be grown cheaper and better in every way.

The enterprise can be congratulated on having passed its experimental year with quite favorable results. It has put Ohio in the list of sugar-producing States. There are many districts in the State where this industry can be established; there is a large local demand

for this product, cheap transportation, a fine quality of coal, and all other facilities for cheap production. It must be looked upon as a State promising much in the future development of the sugar industry.

The factory began its campaign October 26, 1900, and worked up the beets grown on about 2,500 acres.

IN OREGON.

LAGRANDE.—The Oregon Sugar Company established a factory at this place having a daily capacity of 350 tons. This is the only factory in the State, and it made its third campaign in 1900. Oregon was one of the leading States in investigating its conditions for producing sugar beets. Its experiments have been continuous for a series of years. It has been clearly shown that there are several sections in the State well adapted to the establishment of this industry, but none of them up to this time have taken advantage of these conditions except Union County, where this factory is located. The matter has been agitated in other places; partial organizations have been effected, but without material results.

The factory at Lagrande has been laboring under more or less adverse conditions from the beginning. Along with the rest of the coast region, it has been experiencing a continuous and unprecedented period of drought, covering three years. There has not been as much continuous dry weather for many years. The factory was constructed soon after the period began and has never had the opportunity to show the results that might be attained under normal conditions. The farmers hoped each year that these conditions would return, and sugar beets were planted along with other crops only to be followed successively with inferior returns. Everything points to more favorable prospects for 1901; rains and snows have been copious, and they are looking forward to a more prosperous year.

Another backset to the growing of sugar beets resulted from the attempt of the farmers to grow beets on tracts too large for beginners. It was found that the amount of labor required and the cost of production far exceeded those of any other crop to which they were accustomed. This had a discouraging tendency. Those interested in growing sugar beets in any new locality should encourage the planting of smaller fields. After the farmer has grown them for two or three seasons he discovers what the requirements will be in the way of labor, etc., and then he can increase his acreage as his experience and resources fit him to perform the task. He should begin on the smaller plats and work up to the larger ones through a series of years, and not follow a reverse process, as it is feared has been the tendency at Lagrande.

This locality has also suffered more or less from lack of sufficient

and qualified laborers to take care of and harvest the sugar-beet crop. An attempt was made during the last growing season to bring in a lot of Japanese in order to fill this demand. The past season has been quite dry and unfavorable, but on harvesting the crop it was found that the beets were better in quantity and quality than had been anticipated. The factory itself has been thoroughly revised and put in shape for taking care of a sufficient supply of beets when the climatic conditions shall be more favorable. It began its campaign October 1. Many good yields have been reported and the average is fairly good.

Results at Lagrande during the year 1900.

Date of commencing factory operations		1st of October
Date of closing same		5th of November
Number of days operating		36
Number of acres planted to beets		1,803
Number of acres of beets harvested		1,760
Quantity of beets worked	tons..	9,097
Average cost of beets per ton		$4.50
Average yield of beets per acre	tons..	5
Average sugar content of beets worked	per cent..	14.2
Average coefficient of purity		84.1
Amount of sugar produced	tons..	994.9
Sugar in process	bags..	800
Number of employees for the campaign		150

IN UTAH.

The climatic conditions were very unfavorable for growing sugar beets or, in fact, any other crop in Utah during the past year. While the growing of sugar beets is accomplished largely through irrigation, yet irrigation is dependent on the amount of rain and snow which falls in the mountains in the winter. Especially is it dependent upon the snowfall, since this melts gradually and moves down the streams and is conducted out into the irrigating ditches and turned onto the fields during the growing season. The snowfall in Utah was unprecedentedly light, and the State has not suffered in drought so much in thirty years.

The State has grown beets so long and its resources for producing them are so well known that it may be considered as established that drought, disease, and insect pests are about the only things that can cut off an assured crop. During the past season the injurious influences which affected the beets in other sections were not felt in this State, only in a small way hardly worth mentioning. Up to the present time there has been no serious trouble with insect pests. The irrigating facilities are so admirably arranged that no serious consequences can come from a summer drouth. It is only the lack of sufficient fall of snow in the mountains in the winter (the original supply of moisture) that can seriously affect the beet crop in Utah. This failure of snow-

fall in the mountains happened in the winter of 1899–1900, and its result was a poor crop of sugar beets the past year.

LEHI.—The Lehi Sugar Company established a factory of 350 tons at this place in 1891. It is the pioneer factory of the State, and has grown all its beets from the beginning through the aid of irrigation. Experience has shown that rainfall, when it can be had on the growing crop, is preferable. Irrigation is held off and simply used as a last resort when the supply of rain is not forthcoming. It has also been demonstrated that sugar beets can be very easily overirrigated. It has been one of the main difficulties to keep the farmers from giving their beets an oversupply of water. The experience of this enterprise can probably furnish more reliable information on growing sugar beets by irrigation than any other source in the country.

Through the establishment of its pipe lines for conveying juice from substations to the main factory, it occupies a unique position in sugar making in this country. It has two slicing stations, one at Springville, 22 miles south, the other at Bingham Junction, 19 miles north. These auxiliary stations simply extract the juice and transfer it to the factory through the pipe lines. The original working capacity of the main factory of 350 tons of beets per day was increased 350 tons by the establishment of each one of these auxiliary plants. This gives a total capacity of about 1,050 tons of beets per day at the present time. The resources for sugar making of this factory are most carefully studied and managed. During the campaign just closed it worked up 50,000 tons of beets and produced therefrom 5,700 tons of white granulated sugar. It had secured the planting of quite a large acreage, but, owing to the causes already mentioned, the tonnage was quite light, averaging only 8 tons per acre, as compared with 12¼ tons the year previous.

It is quite probable that the company will build another auxiliary plant. It aims to secure the planting of 8,000 acres in beets for 1901, and will pay 25 cents more per ton, based on the same rating for sugar and purity as last year.

A feature in which this company excels is the production of high-grade beet seed. Its production last year was about 40 tons. It began this enterprise several years ago. Its experience has clearly shown that high-grade seed can be produced in this country. Beets from such seed are grown under the same conditions as the beets which produced the seed, and better results are secured than from imported seed.

Along with the rest of the mountain region including the coast, Utah has experienced a heavy fall of snow and rain during the present winter (1900–1901). The main needs of the sugar-beet grower are already assured, and it is probable that this factory will perform the task of working up as much as 100,000 tons of beets next season.

Results at Lehi during the year 1900.

Date of commencing factory operations		27th of September
Date of closing same		10th of December
Number of acres of beets harvested		6,250
Quantity of beets worked	tons..	50,000
Average cost of beets per ton		$4.50
Average yield of beets per acre	tons..	8
Average sugar content of beets worked	per cent..	14
Average coefficient of purity		82
Amount of sugar produced	tons..	5,700

OGDEN.—The Ogden Sugar Company has established a factory at this place having a daily capacity of 350 tons. It completed its second campaign this last year (1900). It met the same adverse conditions as have been already described. It succeeded, however, in securing about 8,000 tons of beets, from which it produced about 2,900 tons of sugar.

The factory had planned to start up the last of September, but in this particular section tomatoes are extensively produced for canning purposes, and since this crop is much more perishable and requires more immediate attention, the farmers were inclined to get it out of the way first. The sugar factory succeeded in making its regular beginning about October 3. It closed its campaign December 11.

The farmers received this year a flat rate of $4.25 per ton for the beets. This would distribute about $119,000 in cash among the farmers of that section. The beets were a little better in their sugar content, but lower in their tonnage per acre than those grown for the factory last year.

It has been planned for some time to double the capacity of the factory. With the present outlook for producing a crop of beets, this will probably be accomplished before the campaign of 1901.

IN WASHINGTON.

WAVERLY.—The Washington State Sugar Company is operating a factory at this place of 350 tons daily capacity. Along with the rest of the mountain and coast region, this section has experienced an unprecedented drought during the past year. The average yield of beets is about 8 tons per acre. But, as has been shown in other localities similarly affected, the beets have a very high percentage of sugar, ranging over 17 per cent, with a purity coefficient averaging over 86.

The factory is anticipating much better conditions for next year and is making a strenuous effort to increase its supply of beets. Pledges were made by the Commercial Club of Spokane to furnish the product of 1,000 acres planted in that vicinity next year. The manager of the factory agreed to pay $4 per ton for beets yielding 12 per cent sugar and 25 cents extra for each additional per cent of sugar shown. He

[illegible] money during the spring [illegible] the expenses of growing the crop, including the same when the beets were harvested and delivered to the factory.

The [illegible] pounds of sugar. [illegible] in bounty to the State $11,325. Indications point to a more successful campaign for 1901.

IN WISCONSIN.

Watertown.—The factory at Menominee Falls, which has been running for some years, has been bought up by a new company. It has a working capacity of 350 tons of beets daily. It will be operated next year by the Wisconsin Sugar Company. It is offering $5 per ton for beets and paying an additional amount on a rising scale, based on the sugar content, up to $5 for beets showing 18 per cent or over. The failure of this factory to operate in the past has had a depressing effect on the industry in Wisconsin. That State possesses many localities available for its introduction. This new turn taken by the factory at Menominee Falls will probably have much effect in increasing interest in sugar production in the State.

NEW FACTORY ENTERPRISES.

The year has been marked with activity on the part of local organizations and capitalists. Many new projects have materialized into actual organization and capitalization, followed by contracts for building factories for the campaign of 1901. Several other projects are on the eve of consummation, so that we can look to the coming year as one furnishing more new factories than any preceding year. This activity is not confined to any particular section, but appears generally in all parts of the sugar-beet growing territory.

Several things have united to make factory building a rather cautious and conservative process. Capitalists have waited to gather as full and complete information as possible relative to the ability of the industry to justify the claims made for it. They have waited anxiously for the development of the policy that shall prevail touching the importation of sugar from our insular possessions. A more intimate acquaintance with our own resources, along with a more settled conviction regarding the future career of the island sugars, has given factory building a more healthful status. We can consider that the era of factory building has been finally and permanently inaugurated.

In outlining the increase in available output of sugar for each year it must be remembered that this takes place not only through installing new factories, but through the extension of the capacity of those already established. There are but few factories in this country that have not doubled or trebled their capacity after the first year or two.

Those that have not done so are making every arrangement to do so. This doubling up as it occurs should be credited to the year's work in factory building. It adds as much to the increase of sugar production as if new factories had been installed representing a capacity equal to the increase. We shall have occasion to mention in this list of new enterprises this extension of capacity where known.

The following is a brief review of the new factory enterprises arranged in the order of the States in which they are located:

IN COLORADO.

As attention has already been called to the results attained in the Arkansas Valley, Colorado, where sugar beets were grown and new factories were in operation the past year at Rocky Ford and Sugar City, but little need be said in this connection.

The American Beet Sugar Company established a factory at Rocky Ford having a daily capacity of 1,000 tons. In order to secure a supply of beets the company controlled most of the land and leased it to the farmers at $4 per acre, the company furnishing the implements. About 4,000 acres were put under irrigation and cultivation. Irrigation appears to have prevented injurious attacks of insect pests.

The Denver News said at the close of the campaign with reference to this factory:

> The American Beet Sugar Company finished paying to-day for October beets. The sum of $152,000 has been paid to the farmers. Instances are numerous of profits of $100 per acre net and few are realizing less than $50. The American Beet Sugar Company is so well satisfied that the soil and climatic conditions in this valley are just right for the raising of beets of high percentage of sugar that arrangements are already about completed to double the capacity of the Rocky Ford factory.

This was the first year; the yield was high and the quality was good. This region presents a vast amount of territory available for growing the same kind of beets, and several projects are on hand to establish factories.

At Sugar City, in the same valley near Rocky Ford, another factory was started. Most of the beets covering 2,500 acres were planted on sod land, which was put to the test of growing a crop of sugar beets the first year. As an item showing the power of this industry in building up communities, the following is quoted from the Denver Republican:

> Sugar City is a new town in the Arkansas Valley which has grown up in consequence of the establishment of the beet-sugar industry in that vicinity. The National Sugar Beet Company is erecting a factory at that point and many farmers in the neighborhood have planted beet crops for the purpose of supplying the factory, which will be completed this fall (1900).
>
> Already Sugar City has a population of over 1,200 and mechanics have more than they can do erecting houses for the inhabitants, some of whom are living in tents. It is expected that there will be a large addition to the population before the end of

the summer, and everything shows that a prosperous community has been added to the number of Colorado towns. The results of the establishment of the beet-sugar industry in one part of the State is suggestive of what may be looked for when the production of sugar becomes one of Colorado's great sources of wealth.

The history of Sugar City will be repeated in large additions to existing communities, if not in the establishment of new centers of population. Grand Junction, where a sugar factory was erected last year, is enjoying greatly increased prosperity and the same is true of Rocky Ford, where another large factory is in course of construction.

In California the introduction of this industry in different parts of the State caused radical improvements in the communities thus favored, and valleys previously little better than deserts were made to support large populations.

Colorado is in both climate and soil so well adapted to the growth of sugar beets that no one can doubt that it will take a leading place among sugar-producing States. There is a sufficiently large market within and tributary to this State to support a dozen or more factories, each of which would exert a stimulating influence like that seen at Sugar City and in other localities where the industry has been started.

Here again experience with irrigation demonstrated that its application was a good means of destroying obnoxious insects that attack the beets.

For some years experiments have been carried on in the vicinity of Loveland, Colo., to test the availability of this section for producing sugar beets of good quality and quantity. Favorable conditions were shown so far as experiments could demonstrate the same. The Loveland Sugar Company was organized and offered $1,000 in prizes to sugar-beet growers for more effectually making these tests. The beets grown were to be delivered to the factory at Grand Junction. Prizes were distributed as follows:

For the person growing the most sugar on 5 acres: First prize, $125; second prize, $75; third prize, $50.

For the person growing the most sugar on 10 acres: First prize, $175; second prize, $125; third prize, $50.

For the person growing the most sugar on 15 acres: First prize, $200; second prize, $150; third prize, $50.

The results of these prize tests were so highly satisfactory that capitalists of Denver and Colorado Springs organized a company and contracted for a plant having a daily capacity of 1,000 tons. Contracts were secured with the farmers for growing the supply of beets and the factory will be in operation in the campaign of 1901.

IN INDIANA.

Last year a company was organized to establish a factory at North Judson. Contracts for several thousand acres of beets were made with the farmers. The beets were to be grown in 1900 for use in the campaign of the factory in the fall. For some reason this enterprise fell through, and arrangements were made to have the beets grown for the factory at Pekin, Ill., and some of the factories in Michigan. The question of building a factory was put over to 1901. This has

iven the farmers some useful experience. I have been informed everal times by the projectors of this enterprise that the factory will urely be built. It will be a factory of rather large capacity, and it vill place Indiana in the list as a sugar-producing State.

Shelby, Ind., is also growing beets commercially upon quite an xtensive scale for factories outside the State. This place has been vorked up to the point of establishing a factory for some time. Stock as been subscribed to the amount of $500,000. Parties owning large racts of land in this vicinity are interested. The factory will be built nd in operation for the campaign of 1901.

IN IOWA.

In Iowa there are many projects under consideration for introducing he sugar industry into the State. There is scarcely a neighborhood n the northern half that has not been accurately tested through the fforts of the State agricultural experiment station and local organizaions. It has been demonstrated that most of the places tested are available for growing a good quality and high tonnage of beets. The surety of a crop is an item in favor of this section. These experiments have been so numerous and so thorough that localities are practically resting on facts already ascertained, awaiting the action of capitalists looking for desirable places. Active effort has centered in a few places—Clear Lake, Iowa Falls, Storm Lake, Mason City, and Fort Dodge. These places all have active local organizations. Each of them grew from 150 to 200 acres of beets on 1 to 5 acre patches for the Minneapolis factory during 1900. I visited many of these fields just before the harvest and never saw better looking beet fields.

This was the first practical effort of these farmers, and the expense was higher than necessary. Had the beets been produced at an ordinary expense, the net profits of many of the fields would have purchased the ground the beets grew upon. The establishment of factories at several or all of these places may be looked for in the near future. Certainly no other places could present a stronger array of advantages when we consider the facilities for manufacture—cheap raw material, a large and assured crop every year, and an available market.

IN MICHIGAN.

Michigan seems destined to occupy the first place in sugar production. The present is her third year in experience in this work. She already has ten factories in operation and seems likely to start several more in the near future. This is one of the favorable indications of the progress of the industry. Results already obtained by the factories at work appeal to capitalists for continued investment.

The capital has been subscribed for building a factory at Salzburg,

a suburb of Bay City. The new feature about this concern is that it is cooperative to a considerable degree. About 1,000 farmers have invested in the stock and are to pay for the same in beets. The factory will be erected in 1901, and will have a daily capacity of 500 tons.

The Saginaw Sugar Company was organized at Saginaw with a capital of $300,000. The majority of the stockholders are from Saginaw. Some of the stock was taken in Cleveland, Bay City, Cheboygan, and Cairo. The contract has been let for building a $500,000 factory, having a daily capacity of 600 tons.

The Lansing Sugar Company was organized at Lansing with a capital of $300,000. Contracts have been secured from the farmers to produce the beets and the contract for building the factory has been let.

There is a strong probability of establishing factories at Dundee and St. Clair in the near future. It is claimed that the money has been partially raised for building factories at both of these places. Many other places are in indefinite stages of factory-locating development.

IN NORTH DAKOTA.

A sugar company has been organized at Fargo. A finance committee is proceeding with the work of raising capital and securing contracts with the farmers for growing the beets. Indications point to the success of the enterprise.

IN OREGON.

The citizens of Newberg, Oreg., have secured contracts with the farmers for growing 6,000 acres of beets on representation of capitalists that a factory will be built if contracts are secured. It is probable that a factory will be built here for the campaign of 1901. It is to cost $800,000 and will be located on the banks of the Willamette River.

IN UTAH.

The Utah Sugar Company, of Lehi, last year trebled its working capacity for the purpose of working up the juice from the two auxiliary plants established, one 22 miles south, at Springville, the other 19 miles north, at Bingham Junction. The factory is planning to put in another auxiliary plant about 14 miles south, using a pipe line already established.

These auxiliary plants simply extract the juice from the beets and transfer it to the main factory through pipe lines for further treatment.

A company was organized at Logan and a factory is now building with a daily capacity of 350 tons. Contracts with the farmers have been secured for growing 4,000 acres of beets.

The Utah Sugar Company, of Lehi, is planning to build a factory in Sanpete County, 125 miles south of Lehi, to be in readiness for the

OF THE
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CALIFORNIA

campaign of 1902. The arrangements have been made, with every probability of materialization.

The Ogden Sugar Company has completed plans for doubling the capacity of its plant.

IN SOUTH DAKOTA.

At Aberdeen there has been much activity for some time in an attempt to secure a sugar factory. The local organization has several times had under consideration propositions from Eastern capitalists. Negotiations have been constantly directed toward the establishment of a factory. The following is clipped from the Oxnard Courier, of California:

T. C. R. Crowell has offered to build a $600,000 beet-sugar factory at Aberdeen, S. Dak., if the citizens will subscribe for $200,000 of the stock, donate a site of 20 acres of land, exempt the property from taxation for twenty years, and guarantee that the farmers will produce 6,000 acres of beets a year. If erected, the factory will be a brick and stone affair, six stories high, and 175 by 400 feet. A committee of citizens has been appointed to take the matter in hand, see about securing a sufficient beet acreage, and also to attend to everything that will have to be arranged before the factory can be looked upon as a settled fact.

A company organized to build a factory at Oakes, N. Dak., has been incorporated under the State laws of New Jersey with a capital of $600,000. The contract has been let for building a plant with 1,000 tons daily capacity.

Several other places will probably mature plans for entering the field of sugar manufacturing in 1902. The two mentioned above will pave the way, and demonstrate what can be done in South Dakota in this direction. This will afford the other places abundant information for materializing their plans.

IN WISCONSIN.

Several years ago a factory was built at Menomonee Falls purporting to have a daily capacity of 350 tons. This effort was the one failure of factory building in the United States in recent years. The availability of its farming district had been thoroughly tested by the State agricultural experiment station at Madison. Contracts were made with the farmers to grow about 3,000 acres of beets. The factory was built, but was very late in its completion. The farmers grew a good supply of desirable beets. These beets were delivered to the factory. Owing to its not being completed, the beets were siloed in the ground surrounding the factory.

The factory had a very adverse career from the beginning. It started up, made a few pounds of sugar of poor quality, closed down, and passed into the hands of a receiver. There it has remained. It began the work of its campaign late in the winter. It was found that the

beets were rotting in the ground and deteroriating. This was given as one of the reasons for the failure of the factory. The loss to the farmers who grew the beets was almost a total one. Several efforts have been made to revive the enterprise, but none matured until the present one. Farmers hesitated to grow beets, remembering their past experience. This factory has been bought up by a new company, reorganized with new capital, and is being overhauled and put into shape for the campaign of 1901. The farmers demanded a security bond of $25,000 guaranteeing payment for their beets. These conditions have been met, and Wisconsin is to enter the list of active sugar producing States.

Indications are favorable for the establishment of factories at Green Bay and Canary.

IN OTHER STATES.

There are many places in other States besides those mentioned above where the subject of establishing factories has received very careful attention. In some cases factories are on the eve of materializing. Probably several communities will be able to establish factories in time for the campaign of 1901 or 1902. I have made every endeavor to get data regarding these proposed factories, but have not been able to get definite information. They are scattered throughout the sugar belt, east and west, some in New York, some in Indiana, Ohio, and Illinois. California has two or three well-matured plans, the details of which have not yet been given to the public, but they will probably result in the establishment of more factories in that State in the near future.

INSECTS AND DISEASES AFFECTING SUGAR BEETS.

There is no royal road to industrial accomplishments. The experience of the beet-sugar industry during the past year has been such that it is thoroughly alive to this axiom. The conditions of climate throughout the whole of the country has been, to say the least, peculiar. Most all of the regions record periods that were intensely hot, followed or preceded by heavy rainfall. The crops developed an abnormal tendency to disease and an unusual amount of attack by their insect enemies. The diseases that seemed most destructive came in the form of root blights, root rots, and leaf blight. There has seemed to prevail all the ordinary troubles that usually affect a crop of beets more or less, but the damage from these has not been extensive. In addition to this, there seems to have been at least three distinct diseases resulting in blight and rot, the symptoms and effects of which were different in the different localities. In places these diseases have produced quite serious results, in some instances destroying the entire crop, and in others resulting in greater or less injury to

the crop. These beet diseases were serious, both in California and Nebraska.

There has been a tendency on the part of the public to classify these diseases under the head of "root blight" or "root rot." Their seriousness has been such as to arouse considerable alarm among the factory people. Some have gone so far as to send agents to Europe to investigate the diseases affecting beets there, and the means used to eliminate the same. Considering it to be a matter of importance to accumulate as nearly as may be all available information regarding the diseases and insect enemies of sugar beets, I immediately entered into correspondence with the State experiment stations, calling their attention to the injuries to the beet crops. I asked that the botanists and entomologists secure specimens; visit the fields where practicable; study the different forms of disease and the insects prevalent; ascertain the manner of attack, the symptoms indicating the same, and the cause. I also insisted that the first prerequisite in entering into this contest with the enemies of the beet crop was an accurate outline of each disturbing element, defining plainly the symptoms and name with any treatment that might meet the situation.

In the pages following the results of the investigations made by these experts are given at some length in order that a beginning may be made in the compilation of authenticated data. These attacks are bound to recur from time to time. As the industry grows, these diseases may spread with it, and it is possible that we will have others with which we have not yet had any considerable experience.

There are insects and diseases affecting other crops which may find in this new one, when it becomes extensive and common throughout the country, a fertile field for attack. The beet may present the very condition necessary for stimulating their propagation, growth, and increase. The habits of life and modes of reproduction are known to the scientists. It is well to make the results of their investigations as available as possible in order that those interested may be equipped with a knowledge of the same and the best methods of combating them.

It will not do to become discouraged and relinquish our efforts because of these difficulties. In other lines of agricultural industry similar difficulties must be met, such as scale on the fruit crop; rust, smut, chinch bugs in the cereal crops; scab, rot, and nematodes in the root crops. These have been matters of careful study, and, through vigilance and right methods of prevention and extermination, we are able to bring our annual quota of these products to the markets.

The writer personally investigated the diseases affecting the beet crop in many sections of the country. The one that appeared most destructive came in the form of a root rot. This disease seems to affect the whole plant, and after it has developed for a time is transmitted to

surrounding beets, especially those in the same row. After a little experience it is very easy to detect the beets affected. The outside leaves turn black and die away; the leaves in the center of the crown have a dark green color, grow short and present a curly appearance. In the substance of the leaf between the veins appear raised places presenting a blistered appearance. A condition that is always shown in affected beets is the dark rings which appear outlining the fibro-vascular bundles. When the beet is cross-sectioned, these dark rings are quite pronounced, showing up quite plainly against the ashen color of the other tissues of the beet. If the beet is cut across, after a few minutes, these rings become much darker. In case of beets in which the disease has developed for some time, a black substance seems to exude from these rings and deposit itself upon the surface.

The sugar content of the beet runs down quite materially as the disease progresses. Finally, the beet becomes completely decayed, the rotting beginning with the tap root and progressing up the beet. There is a tendency for the leaves to become less in size and more curly in appearance as the rotting process continues. The leaves finally die; the top and the whole beet is consumed and stands a rotten mass in the ground. During the progress of the rotting quite an odor can be detected.

There seems to be another disease affecting the beets that is a modification of this one. The curled leaves are present, also the dark rings are found by cross section, but the rotting begins in the crown and goes down. The disease described above appears to be the one investigated by the experiment station at Purdue University, Indiana. This was the work of the botanists, Dr. J. C. Arthur and Miss Katherine E. Golden, the investigations covering the years 1891 and 1892 and being published in bulletin form.[1] A very exhaustive account of these investigations has recently been prepared by Clara A. Cunningham. The determinations of Dr. Arthur and Miss Golden, as outlined by Miss Cunningham, represented the disease as being of a germ origin.

I noticed another affection, which seems to be distinct from the one above. The leaves turn black and die down, leaving the root in a very withered, flexible condition. The root and the tissues of the same take on a dark-yellow cast, but there is not the tendency to rot.

There is another disease that appears to be quite prominent that affects the leaves, and, consequently, the growth of the beet. But my examination of this was too limited to justify an attempt to describe it.

The sum total of the damage done by diseases to beets throughout the country during 1900 was not one of vital moment. But it indicates that the beet-growing industry is not going to escape the diseases which have prevailed throughout Germany, France, and other countries.

[1] Bul. No. 39, Indiana State Expt. Station.

Among the practical questions to be determined in connection with bacterial diseases of beets are the following: Is it safe to plant a crop of beets the following year on land producing an infected crop? Will freezing destroy the germs? Will plowing aid? Should this land be planted in something else? What can be done by the farmer to rid the land of the infection? How long should sugar beets be kept off the land? These are questions of vital importance to the farmer which the experiment stations might investigate.

REPORTS OF SCIENTISTS.

In response to communications sent to scientific workers in several State experiment stations the following reports were received, which will be very interesting and helpful to sugar-beet growers and those interested in the sugar industry. These reports cover most of the diseases affecting sugar beets in this country, and especially those that were prevalent during the past season.

A Bacterial Disease of the Sugar Beet.

I reproduce here part of an article bearing the above title, prepared by Clara A. Cunningham and read before the Society for the Promotion of Agricultural Science at the Boston meeting, August, 1898. The work of Miss Cunningham was the continuation and completion of an investigation and study made by Dr. J. C. Arthur and Katherine E. Golden, and published in the form of a bulletin by the State agricultural experiment station of Purdue University. This article by Miss Cunningham appears to cover completely the disease that was most virulent and least understood, and which appeared among the sugar beets in Nebraska and California the past season. The symptoms of the disease and the facts concerning its progress and development are very accurately described in this article, which was sent to me by Dr. Arthur himself in response to a letter of inquiry. I consider it a valuable compilation.

The letter of Dr. Arthur, together with the article of Miss Cunningham, follows:

Purdue University Agricultural Experiment Station of Indiana,
Lafayette, Ind., January 8, 1901.

Dear Sir: I have just returned from my holiday vacation, and find your letter of 21st ultimo awaiting me. What appears to pass under the name of root rot of beets does not seem to occur in this region, at least it has not so far attracted my attention. A disease which occurs each year to a limited extent has been discussed in the bulletins of this station as a bacterial disease. I send you herewith an account of it by Miss Cunningham, which needs no additional comment.

Yours, truly, J. C. Arthur.

In the autumn of 1890 Prof. H. A. Huston, chemist of the Indiana experiment station, noticed that the analysis of some sugar beets showed a much lower percentage of sugar than others, and the difference seemed to be associated with a slight

change from the usual appearance of the tissues of the root. This observation led to a microscopical examination of the affected beets by Dr. J. C. Arthur, who discovered the presence of bacteria in the tissues, to which, after further study, was attributed the abnormal condition of the beets. During the year 1891–92 the characteristics of the disease were studied by Dr. Arthur and Miss Katherine E. Golden, and the results published in the form of a bulletin in 1892.

This preliminary series of investigations determined that the disease was associated with a specific germ, which could be readily isolated from the diseased tissue.

No similar disease of the beet had been reported from any other locality in America at the time of the publication of this work. Dr. Ernest Kramer in 1891 reported a bacterial disease of the beet root attacking the fodder beets of Russia, and almost simultaneously Dr. Paul Sorauer, of Germany, reported a disease of the sugar beet of that country. In the Export of 1894, Dr. Sorauer gives his opinion that the disease of the fodder beet, named by Kramer *Bacteriosis gummosis*, and that of the sugar beet similarly named by himself *Bacteriose gummosis*, are identical, and perhaps very closely related to the bacterial disease of sugar cane known as "sereh."

The diseased beets, as observed in Russia, are described as having dried leaves with withered heart leaves. The roots of badly diseased beets were so tough they could scarcely be broken, the broken surfaces soon turning black. These beets produced a pathogenic effect on cattle to which they were fed. Many of the diseased beets when first sectioned appeared perfectly sound, but after a few minutes the fibrovascular bundles turned dark and a sirup-like gum exuded from the cells. In other beets the tissue was sometimes completely broken down.

Dr. Sorauer says: "The similarity between the beet and the sugar-cane disease, 'sereh,' consists in the destruction of the cane sugar and the increase of the invert sugar as well as the coloring of the vascular bundles and the entrance of bacteria." He also believes that the disease discovered in America by Arthur and Golden may be the same as that determined by Kramer and himself in Europe.

Mr. Walter Busse, in 1895, took up anew the study of the *Bacteriosis gummosis* of the sugar beet, the material for study being sent him by Dr. Sorauer. In describing the diseased root he speaks of the gum-like fluid as follows: "Soon after the drops appear on the surface of the sectioned beet they are covered by a thin black membrane, which consists of small, black, round bodies of different sizes."

The aim of Mr. Busse was first to determine the form of bacterium common to all the diseased beets by the separation of the germ from the diseased tissue, and second, to demonstrate that this was the specific cause of the disease by inoculating healthy beets with the germ. In the first series of experiments three germs were isolated. Two of these were discarded and the third form was kept for further observation. * * *

Mr. Busse is inclined to believe that the second form is a variety of the first, which he designates as *Bacillus betæ*. He has demonstrated that this second form produces the disease known as *Bacteriosis gummosis*, and believes that this germ is a saprophyte, which becomes a parasite in the tissues of the beet.

Erwin F. Smith, in speaking of the bacterial diseases of the sugar beet as reported from Europe and America, is of the opinion that the diseased condition of the beets studied by Arthur and Golden is due to some other cause than a bacterial one. He states that it is highly improbable that the root could be attacked by an organism which invades its tissues and yet does not break them down. Mention is made of the fact of the presence of small bodies in the tissue of healthy beet roots which have the appearance of bacteria, but which are probably crystalloid bodies. A paper by Dr. Smith was presented at the meeting of the Society for Plant Morphology and Physiology in December, 1897, calling attention to the existence in parts of the United States of a disease of the sugar beet resembling, if not identical with, that described by Kramer and Sorauer in 1891–92 and more recently by Busse.

In the fall of 1896 I had the opportunity to continue the investigation of the bacterial disease of the sugar beet observed in Indiana in 1890–91. Much of the value of my experimental study of this disease is due to the suggestions of Dr. Arthur, to whom I am indebted for kindly help and criticism of my work. I also desire to express my gratitude to Professor Burrage, Professor Huston, Miss Golden, and Mr. H. L. Bryan, also of Perdue University, for important suggestions. My investigations, which have been continued from 1896 to the present time, have resulted in no positive evidence that the sugar-beet disease of Indiana is the same as that described by Sorauer and Busse, of Europe. The points of similarity will be noted in the following description of the disease and of the germ by which it is produced:

About the middle of September, 1896, several diseased beets were found in the field of cultivated beets on the grounds of the Perdue experiment station. The disease attacks the whole beet plant, causing a peculiar appearance of the leaves, so that with a little practice the diseased beets can be distinguished readily from the healthy ones as they grow in the field. The outer, older leaves soon die away, and the intermediate and heart leaves are left wrinkled, curled, rather flabby than turgescent, and of a yellowish-green color. This wrinkled appearance is caused by blister-like patches being formed between the veins of the leaf, and the whole has been described as resembling a Savoy cabbage leaf.

The appearance of the exterior of a beet root when diseased is not materially different from that of the healthy beet. It is perhaps not quite as brittle. A decisive test for the disease is found in the appearance that the root shows when sectioned. The fibrovascular bundles appear as dark rings in the white flesh. They grow almost black after being exposed to the air for a few minutes. These rings are quite distinct from the cream-colored fibrovascular bundles of healthy beets.

In 1896, in a field of beets covering an area of about 1 acre and containing approximately 130,000 beets, 11 badly diseased and several slightly affected ones were found. This was a smaller number than had been found on the same ground in previous years, and can perhaps be accounted for by the climatic conditions being so favorable to plant growth the preceding summer, there being an abundance of rain. The number of diseased beets increased, however, toward harvest time.

Frost seems to be much more injurious to the diseased than to the healthy beets. The heart leaves of the diseased beets were more easily injured by the frost. It is characteristic of the disease that the leaves of badly diseased roots die away until no green leaves remain, leaving an apparently dead root in the soil, though its tissues will be found to be firm and not in the least broken down. The early frosts hasten the destruction of the leaves. Both diseased and healthy roots show an acid reaction, the diseased seeming slightly more acid than the healthy. * * *

It has been determined that a microscopical examination of the tissues of the diseased beets reveals the presence of bacteria in the cells of the plant. The tissues of the plant are not broken down, and the bacteria in all parts of the plant appear to be the same. Transfers of diseased tissue to the healthy beet root resulted in changed appearances of the plant which indicated almost certainly that the disease was transmitted.

The manner in which the germ finds entrance to the plant has not been determined. The conditions most favorable to the attack are those resulting from drought with succeeding low temperature.

The fact that the germ breaks down cellulose slowly explains the manner of its progress from one cell to another.

Experiments have shown that the germ in a medium containing a low percentage of acid grows nearly or quite as well as in one of alkaline nature, so that the acid element of the beet root does not offer material resistance to the germ.

The germ converts cane sugar into glucose in the process of producing gas. The amount of gas produced is not constant, but the reasons for this irregularity have not been determined.

The germ grows well with any form of sugar, and especially well in media containing cane sugar. This fact makes it seem probable that the germ is especially a home on those media which contain sugar in some form, although it will keep also on media without sugar, and after cultivation for a time on such media will adapt itself to the conditions presented.

The colorless gelatinous form separated from the beet root in connection with the disease germ was at first thought to be an undescribed germ or rather the product of a germ, for only a few bacterial bodies could be detected under the microscope even when comparatively large masses of the substance were placed in the field. The organism appeared as small bacilli or micrococci.

The mass resembled the form of Leuconostoc so common in the vicinity of sugar refineries. Under the microscope, however, no streptococci were found, which characterizes Leuconostoc under the microscope. The gelatinous substance is soluble in water and alcohol; in the latter it turns to a milk-white substance before it dissolves. The substance increased rapidly in bulk when grown on sterilized beet. The mass did not dry out for months after the substratum had become dry and hard.

The substance grew well on 10 per cent cane sugar agar. The growth was slow at first, but after a week or two masses measuring a quarter of an inch in thickness and three-fourths of an inch in circumference, collected on the surface of the medium in stab and slant cultures. In case of stab cultures the agar was broken vertically along the line of inoculation. The colorless growth followed this break in the agar, and as the substratum became hard the mass collected as a colorless semifluid in the bottom of the test tube.

On slant agar there was a thin colorless layer, imparting a fluorescent hue to the medium. In agar plate cultures the organism formed small round colonies about the size of a pin head, resembling a small drop of water. These colonies were sometimes found with the disease germ, in plate cultures taken directly from the beet. It grew on sterilized potato, and to some extent on gelatin. Immediately after separation from the beet root the organism produced fermentation, but the power was lost after a time. Staining revealed only a structureless mass containing a few bacteria-like bodies.

Desiccation has little effect on the substance. Sections of beet on which the organism was growing have been kept in the laboratory until they are quite dried out, and the gelatinous mass is still apparent.

If this is indeed a form of Leuconostoc it is interesting to find it in diseased beet roots.

Work Done in the U. S. Department of Agriculture.

No exhaustive investigation of sugar-beet diseases has yet been made by the scientists of the Department of Agriculture. The following letters explain themselves:

U. S. Department of Agriculture,
Division of Vegetable Physiology and Pathology,
Washington, D. C., September 24, 1900.

Dear Sir: Your letter of September 15, addressed to the honorable Secretary of Agriculture, has been referred to this Division.

The beets sent in by Mr. H. S. Ferrar, of Grand Island, Nebr., have been received and examined. We have reported to Mr. Ferrar on the beets, and inclose a copy of our letter to him.

One of our men has been detailed to the study of beet diseases, and is already at work in California. There is no doubt that a number of diseases have become epi-

demic, and a thorough investigation of all of them is demanded. We trust that sufficient funds may be secured to carry out this matter.

Please let us hear from you whenever you come across anything which needs our attention.

Very truly, yours,

B. T. GALLOWAY,
Chief of Division.

Mr. CHAS. F. SAYLOR,
Special Agent, United States Department of Agriculture.

U. S. DEPARTMENT OF AGRICULTURE,
DIVISION OF VEGETABLE PHYSIOLOGY AND PATHOLOGY,
Washington, D. C., October 19, 1900.

SIR: I beg to acknowledge the receipt of copies of letters of Mr. C. F. Saylor, special agent in charge of sugar investigations, and to submit the following brief report on root blight in sugar beets.

At the present time there is no means of identifying the so-called root blight with any disease of the kind occurring in Europe, and the investigations which this Division has been conducting so far show that the root blight of Michigan, Nebraska, and Colorado is not the same in all cases. It is very likely that a number of diseases are confused under this one name, and a thorough investigation is necessary before anything definite can be reported. As indicated above, this Division has inaugurated an investigation of this disease, and it will be pushed as rapidly as possible.

There is no doubt that the epidemic nature of a number of beet diseases is due to the unfavorable weather conditions the past season.

Very respectfully,

B. T. GALLOWAY,
Chief of Division.

The SECRETARY OF AGRICULTURE.

U. S. DEPARTMENT OF AGRICULTURE,
DIVISION OF VEGETABLE PHYSIOLOGY AND PATHOLOGY,
Washington, D. C., September 24, 1900.

DEAR SIR: The beets forwarded to us at your request and Mr. Saylor's have been examined. We find that a fungus closely related to the root-rot fungus of cotton, cowpeas, etc., has attacked the lower part of the tap root and the fine feeding roots in all the specimens. It works in through the water-conducting bundles of the roots and finally up into the main beet root, causing a browning and drying out of the tissues and a blackening of the vascular bundles when, after the root is cut, it is exposed to the air. This blackening will occur at some distance beyond where the fungus is present. The indications are that the fungus is the prime cause of the trouble, though this could be determined only by careful field investigation and a long series of experiments testing the question of the parasitic nature of the organism, as it is accompanied by bacteria and yeasts in the tissues. Of course it may have been that the young feeding roots were killed by something else and the fungus followed as a secondary thing. The same blackening and browning of the vascular bundles is caused by the leaves being killed or seriously injured before the beet root is matured. This sometimes occurs as the result of an attack of leaf spot, produced either by the ordinary leaf-spot fungus (*Cercospora*) or the large leaf-spot fungus (*Phyllosticta*). Very serious injury has been caused by both these organisms in Michigan this season and the effect on the beet is much the same as the work of the root-rot fungus attacking the beets around Grand Island.

We are asking for an increased appropriation this year in order that we may make a thorough investigation of the beet diseases. The matter is of great importance, as some of the diseases have assumed epidemic character and bid fair to destroy the beet industry in several regions unless something can be done to check them.

Assuring you of our willingness to do anything within our power to help the beet growers and the sugar industry, I remain,

Very truly, yours,

B. T. GALLOWAY,
Chief of Division.

Mr. H. S. FERRAR,
Manager American Beet Sugar Company, Grand Island, Nebr.

WORK DONE IN NEW YORK.

Considerable attention has been devoted to the diseases of the sugar beet by the scientific workers of the experiment stations at Ithaca and Geneva, N. Y., as is shown in the following letter and articles:

CORNELL UNIVERSITY, AGRICULTURAL EXPERIMENT STATION,
Ithaca, N. Y., January 8, 1901.

DEAR SIR: In reply to your letter of December 28, sent to the entomologist of this experiment station, I may, as botanist, be able to tell you something of the root diseases of sugar beets most abundant in this State.

No bacterial diseases from this State have as yet come to my attention.

Beet root rot, caused by a species of *Rhizoctonia*, was abundant in 1898, and has since been found to a slight extent. A complete account of this disease will be found in Bulletin No. 163, Cornell Experiment Station, and inclosed I send you a briefer account of the gross characters, this printed account being part of a forthcoming bulletin (No. 186) of this station in cooperation with the Geneva Station (by B. M. Duggar and F. C. Stewart).

Beet scab, apparently identical with potato scab, is abundant.

Leaf scorch of beets sometimes leads to a discolored root, and so I include an abstract of F. C. Stewart's report upon this in Bulletin No. 162 of the Geneva Station, particularly as Mr. Stewart requests that I embrace his report in mine.

Very truly, yours,

B. M. DUGGAR, *Botanist.*

Mr. CHARLES F. SAYLOR,
Special Agent, United States Department of Agriculture.

RHIZOCTONIA ON THE BEET (BETA VULGARIS).[1]

Our attention was first called to this disease by specimens of affected beets sent to us from Binghamton. A few days afterwards the disease was discovered as a beet trouble of considerable importance at Cattatonk, N. Y. This occurrence has been fully treated in Bulletin 163 of the Cornell Experiment Station, and at this time a summary of these notes will suffice. At Cattatonk a 3-acre field was attacked so severely that fully one-third of the crop was lost. Diseased plants are usually found in scattered areas throughout the field; but the fungus undoubtedly passes readily from plant to plant in the row and it has a tendency to spread radially. Cold weather or dry conditions quickly retard the spread of the trouble, and it is much more abundant where the soil is moist or the surface drainage bad.

During hot weather the fungus secures a hold most readily at the bases of the leaves, perhaps because here there is moisture with the slighest rain or dew. Inoculation

[1] From Bul. 186, Cornell Agr. Exp. Sta., in cooperation with the N. Y. Agr. Exp. Sta., Geneva, by B. M. Duggar and F. C. Stewart.

experiments also demonstrate that in these parts the disease "takes" well. The progress of the injury may be noted by the blackening of the leaf bases, and finally the wilting and prostration of the leaves themselves. The leaves do not, however, turn brown until after they have fallen. When the fungus has worked into the crown and root proper, a browning of those parts is evident, and finally deep cracks may appear.

The brown mycelial threads of the fungus among the diseased leaf bases are evident to the unaided eye, and after the root has become affected a considerable mycelial weft may be found in the cracks and affected parts. A diseased beet sliced lengthwise and placed in a moist chamber yields in a day or two a luxuriant growth of the fungus.

This disease has since been reported to us in the central and the western parts of the State, but specimens are not seen. During the past season it was found again, in the month of August, at Flint and at Phelps, N. Y., but in neither case was there any serious outbreak of the disease. Specimens collected at the former place showed a considerable development of sclerotia, which bodies had not been previously observed upon the beet. Furthermore, Mr. A. D. Selby has kindly told us that he has found this disease of beets in Ohio during the past autumn.

Inoculation experiments have been made in the field, and these all indicate beyond a doubt that this *Rhizoctonia* may readily produce beet-root rot when the conditions are favorable. Moist conditions are essential for the spread of the disease from plant to plant. Moreover, this fungus taken directly from the diseased beets has the power of damping off lettuce and also beet seedlings.

A beet disease due to a species of *Rhizoctonia* has been known to botanists of Europe since 1855; and we are indebted to Prof. Karl von Tubeuf, of Berlin, for material of that fungus. It is improbable that the American form is identical with the European. However, the disease found by Pammel in Iowa may be the same as the one which we find in New York.

LEAF SCORCH OF SUGAR BEETS.[1]

This trouble was found in certain localities in August, 1899, and seemed to be caused undoubtedly by excessive transpiration during a season of hot winds, and other injurious conditions a few weeks earlier. Sometimes the trouble was manifest merely in the leaf margins. In severe cases, however, the leaf blades were killed, and only remnants of green petioles showed any living tissue in these parts. The root itself was sometimes affected, showing then a brown discoloration extending from the outside toward the center, sometimes to a depth of half an inch. There was no indication of true rot in this affected region. In some cases the fibrovascular bundles extending into the normal tissues were slightly blackened.

RESULTS OF INVESTIGATIONS MADE IN CALIFORNIA.

Sugar-beet diseases have received some attention on the Pacific coast, but not so much as they deserve. Doubtless more thorough investigation will be made in the future. The following letter, dated December 26, 1900, was written by a bacteriologist of the State Experiment Station of Berkeley, Cal.:

DEAR SIR: Your favor of December 21 regarding "root blight" of beets was duly received. Unfortunately, I have been unable to devote much time to the investigation of the beet troubles which have caused so much loss in California during the last two years. My observations have been limited to those made during two short

[1] Adapted from account by F. C. Stewart in Bulletin No. 162 of N. Y. Agr. Exp. Sta.

visits to the affected beet fields—one in 1899 and one in 1900. The conclusions I have come to are as follows:

The failure of the sugar-beet crop in Santa Clara, Santa Cruz, and Monterey counties during the seasons of 1899 and 1900 seems to have been due to three main causes. These are, in order of importance: (1) Drought, (2) "blight," and (3) root aphis. The failure in individual fields was due sometimes to one of these, sometimes to a combination, but was not all due, as popularly believed in the locality, to the new "blight" alone. This cooperation of disease causes makes the definition of the "blight" symptoms somewhat difficult. Several cases were distinguishable:

(1) Rich, loose, well-cultivated soil with abundant moisture; 75 per cent to 95 per cent of the beets missing; 5 per cent to 15 per cent very small; 5 to 10 per cent extraordinarily large and vigorous. In this case it appeared that the blight had attacked the beets when young and killed most of them. A few which were attacked with less virulence were not killed, but the roots were so injured that they were unable to grow large. Most of these had lost their central tap root. The remaining beets had apparently escaped infection and, having all the ground to themselves, had grown to immense size. In all fields exhibiting these characteristics the beets had been planted early.

(2) Similar to the last but only about 30 to 40 per cent missing; very few small and the remainder medium to large. In fields of this character there was often almost a full crop. They were invariably late planted.

(3) Soil not very well cultivated and deficient in moisture; 50 to 75 per cent of the beets missing; the remainder very small; crop a total failure. These fields were planted early.

(4) Similar to (3) but from 30 to 40 per cent of the beets medium to small. These fields were planted late and had from one-third to one-half a normal crop.

We have in these four cases, first: The effect of blight on early-planted fields; second, the effect of blight on late-planted fields; third, the effect of blight and drought on early-planted fields; and, fourth, the effect of blight and drought on late-planted fields.

There seems to be a critical period, due to the age of the beet, to the temperature or the moisture of the atmosphere, or to some unknown weather condition, during which the blight is particularly virulent, and those plants which escape infection at this period remain unaffected and make a normal growth. In 1900 this critical period seems to have been early in the season, as late-planted beets were much less affected. According to the accounts of growers, however, the late-planted beets were most affected in 1899.

Most of the symptoms of the "blight," such as darkening of the vascular rings, softening of the root, excessive growth of short rootlets, are common to other diseases. The only symptom that seems characteristic is a certain crumpling and turning in of the leaves caused by a pimple-like hypertrophy of the veins, and whether this is invariable or not I am unable to say as it seems to disappear as the beets become older.

I am still working on this beet trouble but have not the time or the opportunity to give it the attention it requires. It is of so much importance that I hope a suitable appropriation will be made this year which will enable some one to spend the necessary time in field investigation during the whole beet season, for this is the only way to get at the bottom of the matter.

Yours, very truly, FREDERIC T. BIOLETTI.

In Willett & Gray's Weekly Statistical Journal appears the following description from good authority of the sugar-beet troubles that have existed there:

On the affected plants the leaves curl by turning the backside of the leaf margins upward. The latter looks somewhat coarse; especially along the veins warty, small

elevations can be noticed. The tissue of the leaf seems to be thicker than that of a normal beet. All sick beets show an astonishing number of rootlets, while the normal beets have much less. In an advanced state of sickness, the leaves turn yellow and dry out. The root of the sick beet stops growing. The fertility and nature of the soil is not considered as the cause of this blight; neither is the variety of the beet seed, as the seed is equally distributed on all of the fields. It is concluded that the blight is caused by the dry hot air, the transpiration of the leaves is such an energetic one that the roots are not able to meet the demand for water; therefore the solution of nourishing matter in the leaves gets concentrated enough to hurt the tissue of the leaves, making them unfit to perform the duties of assimilating carbonic acid from the atmosphere to sugar and starch, etc. Furthermore, the water supply accessible to the rootless being exhausted the rootlets die; as soon as water has accumulated again a second growth of rootlets takes place, and so on (being something done very rapidly by beets, sometimes in the course of six hours.) The young beets are not so strongly affected as older ones, as they live on the nourishing stuff accumulated in the seed, but as soon as the surface of the leaves grows large enough in proportion to the rootlets, the effect of the too energetic evaporation of water becomes visible. A similar disease, but in a much more advanced state, was observed in Ontario and Yates counties, N. Y., on beets, cherries, cauliflower, and maple, and was reported in Bulletin No. 162, November, 1899, of the New York Experiment Station. The destruction of the leaves and even of the roots went much further than here, owing to circumstances very favorable to the disease. It is reported that after a sufficient rain the beets started a second growth, but showed a much lower percentage of sugar than normal beets grown in the same field. I believe the same will take place here. The reporter concludes:

Concerning treatment it is needless to say that proper irrigation is a sure preventive, but where irrigation can not be practiced, avoid planting on light, sandy soil, and in dry weather conserve the moisture by stirring the soil frequently, and especially after every shower.

Report by an Iowa Botanist.

Prof. L. H. Pammel, botanist of the Iowa Agricultural College, contributes the following general discussion of the sugar-beet diseases:

Brown root rot of sugar beets (*Rhizoctonia Betæ*).

In the year 1891 the writer became familiar with a root-rot disease that affected sugar beets quite seriously upon the college grounds in which this general statement was made. During the early part of August Professor Curtiss called my attention to the rotting of sugar beets in the ground. It was similar to certain root-rot diseases found on the beet in Europe. It did not appear to be the nematode disease common in Europe, though nematode worms were common in the decaying roots.

After a careful study of this disease the writer came to the conclusion that it is very different from the violet-root fungus so commonly affecting the sugar beets and other root crops in Europe. So far as I know the violet-root fungus has not been found in this country on the sugar beet or mangels, but it does appear upon the alfalfa in Nebraska; therefore, it may be looked upon as a possible source of danger to the sugar beet. The brown root-rot disease undoubtedly should be referred to the one described by a German scientist (Kuehn) and later recorded as quite destructive by Eidam in Germany, this disease affecting not only the large beets but young seedlings as well, sometimes destroying whole patches.

As to the appearance of this fungus in the United States I may say that since its recorded appearance in Iowa in the year 1891, Dr. B. M. Duggar, of the Cornell Uni-

versity Experiment Station, has recorded the fungus as common in New York. He says of the appearance in the vicinity of Binghamton:

Beet root rot was first brought to my attention as a disease of small extent in the vicinity of Binghamton. A few days afterwards it was found abundantly at Cattaraugus, N. Y. A visit to the latter place on August 12 demonstrated that the disease was a matter of considerable practical importance. An examination of a 3-acre field on the premises of Philip Caple convinced me that probably one-third of the beets in this field were affected, and it was then too late to attempt any remedial measures with this root rot. Fortunately, some change in the conditions soon checked it, and my notes represent the final effect of the disease. A careful study of the affected field showed one point of peculiar interest. In certain areas the chipped tan bark of an old tannery had been thickly spread on the land, and in such areas there was not the slightest indication of diseased beets. The tannery product was quite dry, and I attributed the absence of the disease to the lessened water content of the upper layers of the soil, which assumption would be in accordance with the results of some experiments to be detailed later. Again, in a part of the field where coal ashes had been heavily applied, there was a noticeable diminution in the amount of the disease. This disease was afterwards reported from several places in the State, although it has not yet proved a common disease in New York. As mentioned later, what is probably the same disease was reported in Iowa in 1891, and it may have been observed in one or two sections of the country. It may be the same trouble that has several times been very destructive to the sugar-beet industry in Germany. Again, as subsequently noted, this beet rot is caused by the same fungus which causes a stem rot of carnations; and probably by the same fungus which produces some damping off diseases, so that we may predict that it has a wide distribution even at the present time.

Climatic conditions seem to cause a variation in the distribution of the fungus. Some years it seems to be particularly destructive. That was true during the years 1891 and 1892. Since then it has not been common. During the past season, when there was much complaint of root-rot diseases, the fungus was exceedingly rare. The writer found only a few specimens affected. How common it has been in the country this year the writer has been unable to learn.

In the year 1891 I carried on an extensive correspondence with several botanists of the country where experiments were being made with the sugar beet, but I was unable to definitely verify its appearance in any other State except Iowa. Diseased sugar beets were sent from Michigan, but these afterwards proved to be affected with an entirely different trouble. The disease is said, however, to have occurred in a few other places in this country.

I think there can be no question that the disease referred to by Professor Duggar is identical with that previously described by the writer. This disease manifests itself by gradual dying of the plant. Under favorable conditions this root rot seems to establish itself at the bases of the leaves. It is here where the infection apparently takes place, as Duggar has determined by experiment. There is a general tendency for the leaf to become black, then droop and fall to the ground, the leaves remaining green longer than is ordinarily true with other diseases. The chief injury by the fungus is where it works in the ground, where it causes the parts to turn black and ultimately to decay. As the fungus spreads, cracks appear on the surface of the side, until ultimately the whole root falls away. The disease spreads chiefly in the row, causing the so-called dead spots to form. Sometimes a dozen to fifteen plants in a single row and those on the adjoining rows will be affected.

On pulling an affected beet up the diseased part invariably has soil adhering to it, while the undiseased is free. The border line is marked by a brownish color. In very young specimens it is reddish, with the tissues more or less shrunken. A cross section through this part shows that the branched, nearly colorless threads ramify between the cells and intercellular spaces. Occasionally they penetrate the cell and occur in the cell cavity. An affected beet placed in a moist chamber is soon covered with a very dense growth of fungus. Every specimen examined contained this fungus, and frequently many other saprophytic species. Rotting beets give off a very strong odor not unlike that of rotting potatoes.

The technical name of this fungus is *Rhizoctonia betæ*, which is being worked out quite carefully by Stewart, of the New York Agricultural Experiment Station of Geneva, and Dr. B. M. Duggar, of the Cornell University Agricultural Experiment Station. They find the same fungus upon carnations and other plants.

BEET SCAB.

Another root trouble of sugar beets that has been destructive at times is the beet scab. The credit of having first discovered the relation existing between potato-scab fungus and beet scab is due to Prof. H. L. Bolley, of the North Dakota Agricultural Experiment Station. This writer, who had given considerable attention to the subject of potato scab, observed that when sugar beets followed potatoes they invariably produced a considerable amount of scab, and he soon demonstrated that a scab fungus could be established from this fungus beet that was in all respects identical with the fungus occurring upon potatoes.

Since then this fungus has been found widely distributed in the United States. The writer in the year 1891 called attention to its occurrence in Iowa, and since then he has repeatedly observed it on sugar beets. Thus during the past season it was observed on the college farm, and on sugar beets found in the vicinity of Fort Dodge and Webster City, and B. M. Duggar, of Cornell University, refers to its appearance on sugar beets in New York.

The chief characters of this disease are the warty excrescences that occur upon the beet. The scab appears very much like potato scab, being corky and somewhat spongy, the injury being not entirely superficial but ordinarily affecting the tissue immediately underlying. In its life history and development it is very similar to the potato scab, the scab being produced as a result of the development of cork due to the presence of the fungus.

BACTERIOSIS.

During September, when Mr. Charles F. Saylor was here, the beet patches were carefully gone over, and my attention was called to this peculiar disease, and then the writer and Mr. F. W. Faurot made cultures of the diseased beets. From these diseased cultures there were obtained organisms that in their morphology and biological characteristics, so far as they were carried out, answered to the description given by Arthur and Golden, and Cunningham, but the work was not carried sufficiently far, owing to a destructive fire in the laboratory, to determine whether it was pathogenic. However, I am inclined to think from the results of our work, so far as they have been carried out, that it may possibly prove to be the same thing found by these writers.

Mr. F. W. Faurot determined the loss and the percentage of the diseased beets in the field as follows: A count was made of several areas about 10 or 12 feet square with the following results:

Losses of beets from bacteriosis.

Area.	Total number of beets.	Number diseased.	Per cent diseased.
No. 1	50	20	40.0
No. 2	142	72	50.7
No. 3	78	38	48.7
No. 4	101	43	42.5
No. 5	91	59	64.8

The areas counted were selected at random, i. e., in various parts of the field, and no attention was paid as to whether they were in the least or the most affected part.

The spread of disease seemed to be general, i. e., about equally distributed in all parts of the field.

Dr. J. B. Weems, who has paid considerable attention to the chemical analysis of sugar beets, finds the following results of a number of analyses made at the station this year:

Results of analyses of beets, Iowa station, 1900.

No. of sample.	Data regarding beets analyzed.				Results of analyses.			
	When received.	Source.	Variety.	Condition.	Number of beets.	Average weight, trimmed.	Coefficient of purity.	Sugar in the beet.
						Ounces.		*Pr. cent.*
11	Oct. 16	Station plot		Diseased	7	17	65.55	5.[illegible]
12	do	do		Sound	8	22	78.87	9.44
13	Nov. 10			do	10	8	79.77	11.[illegible]
14		C. F. Saylor		Diseased	2	22	70.84	6.38
15	Nov. 10	Station plot	Zehringen	Sound	10	13	78.75	10.[illegible]
16	do	do	Cordes	do	10	16	78.61	10.49
17	do	do	White Vilmorin	do	10	14	72.28	9.29
18	do	do	Kleinwanzlebener.	do	10	11	73.89	10.26
19	do	do	do	do	10	15	70.94	9.56
20	do	do	Australian Special.	do	10	13	67.06	9.06
21	do	do	White Queen of the North.	do	10	12	57.08	9.23
22	do	do	White Imperial	do	10	14	71.39	9.[illegible]6
23	do	do		do	15	20	67.[illegible]6	9.53

The disease is readily recognized by the fact that the older leaves soon die and fall off. The heart leaves and those just outside of these have a wrinkled appearance and of a yellowish green color. This wrinkled appearance and the blister patches are well described and figured by Arthur and Golden,[1] and Cunningham.[2]

The beet has a normal appearance, but a cross section shows that there are dark rings. These occur in the fibrovascular bundles. When exposed to the air for a few minutes they turn almost black. A further description of this disease is given by Miss Cunningham, as follows:

Frost seems to be much more injurious to the diseased than to the healthy beets. The heart leaves of the diseased beets were more easily injured by the frost. It is characteristic of the disease that the leaves of badly diseased roots die away until no green leaves remain, leaving an apparently dead root in the soil, though its tissues will be found to be firm and not in the least broken down. The early frosts hasten the destruction of the leaves. Both diseased and healthy roots show an acid reaction, the diseased seeming slightly more acid than the healthy.

Some experiments were made by Mr. Faurot. Several germs were isolated from the diseased tissue, and one of these corresponded in its biological and structural characters to that isolated by Arthur and Golden, but the work was brought to a standstill by the fire which destroyed all of the cultures and notes. I am inclined to think that the disease is identical with that described by Arthur and Golden.

A bacterial disease of sugar beets has also been described in Europe by Busse, and Dr. Erwin F. Smith has called attention to a sugar-beet disease in America that resembles, if it is not identical with, that described by Kramer and Sorauer as well as Busse.

LEAF SCORCH.

Another disease that seems to affect the amount of sugar contained in the beet roots quite seriously is what is known as leaf scorch, which was described by F. C.

[1] Bulletin No 39: Purdue Univ. Agrl. Exp. Sta. [2] Bot. Gazette 28: 177.

Stewart[1] of the Geneva New York Agricultural Experiment Station in the year 1899. Here is the description of this disease given by Mr. Stewart:

On slightly affected plants the only indication of disease was to be seen in the brown or black dead-leaf margins. In more severe cases the young leaves at the center of the crown were black and dead, as were also the blades of most of the leaves. Many plants showed nothing green but the petioles of the larger leaves. In the petioles of the dead leaves the fibrovascular bundles were not blackened except, perhaps, for a short distance below the blackened blade. In the majority of cases the roots appeared normal, but the plants most severely attacked often showed a brown discoloration of the root. This discoloration extended from the outside toward the center for a distance of from one-fourth to one-half inch. The discolored tissue showed no indication of rot, and was separated from the healthy tissue by an indefinite and somewhat irregular line. The fibrovascular bundles colored somewhat more deeply than the parenchyma, giving a zonate appearance to the affected tissue. The location of the affected tissue could generally be determined before the root was cut open, by the darker color and pronounced elevation of the bark. In some cases when an affected root was cut crosswise just below the crown the fibrovascular bundles were found to be much blackened, but this character was by no means a constant one.

This disease is a physiological one. It is due to the fact that the plant gives off more water than it can take up.

Economic Entomology of the Sugar Beet.

Under the above title the Beet Sugar Gazette gives the following review of an Illinois experiment station bulletin:

A contribution of unusual value to the knowledge of the sugar beet and how to care for and protect it, especially in its infancy, from the numerous insects that continually threaten and often seriously damage it has been made under the above title by Prof. Stephen A. Forbes of the Agricultural Experiment Station of Illinois at Urbana. On account of its instructive character to beet growers and the general treatment of the subject, which brings it within the comprehension of the non-scientific reader, bringing its valuable lessons home to all, the important parts of this essay will be given wider publicity by the Beet Sugar Gazette.

New enterprises—new difficulties; new crops—new insect enemies and old enemies in a new rôle. The recent introduction and rapid extension of sugar-beet culture in America have brought to general notice several insect species not before known as injurious, and have given a new food to others well known for their attacks on the older crops.

The beet plant is very similar as food for insects to some of our commonest weeds, and hence it has attracted the prompt attention of several species which, if we have noticed them at all, we have hitherto regarded as our friends; and it has also served to give additional variety to the diet of several crop insects of somewhat general feeding habits. It has thus already recruited a large entomological following—about 150 species in America, if we put upon the list everything which has thus far been found to feed upon the beet in the field. Most of these, of course, can hardly be called injurious in the economic sense, but with our present knowledge of the subject, about 40 species may be definitely so classed. Furthermore, we may expect additions to this list from time to time, since the necessary concentration of beet culture in the neighborhood of factories and the consequent devotion of large areas to this crop year after year for an indefinite period give opportunity for an extraordinary multiplication and a continuous maintenance of its insect enemies. Doubtless, also, many beet insects, which, in the short period since beet culture began in America, have been present in small or moderate numbers only, will from time to time exhibit that tendency to extraordinary and alarming multiplication common among the injurious species generally.

[1] Ann. Rep. New York Agrl. Exp. Sta., 1899, p. 153.

It must not be inferred, however, that the beet plant is especially liable to insect injury. On the contrary, taking the country at large, it is at present less subject to such damage than corn or wheat, cabbage or potatoes. It is a fact particularly favorable to this crop that the marketable part of the plant is but little subject to injury by insects, by far the greater part of the species which feed on it infesting only the leaf, and relatively few injuring the root.

The critical period of insect injury to the beet is in the beginning of the season, while the plants are still small and slow of growth. There is at this time so little vegetation on the ground that a comparatively small number of insects may serve to lay the field completely bare; and poisons are often not available, since a leaf-feeding insect may completely devour the little beet while getting a fatal dose of poison for itself.

The principal injurious groups are the leaf-miners, the webworms, the cutworms, the woolly bears, and several other leaf-eating caterpillars, the wireworms, the white grubs, the flea-beetles, the blister beetles, the plant bugs, the leaf-hoppers, the plant-lice, and the grasshoppers. The webworms, the cutworms, the flea-beetles, the blister beetles, the leaf miners, and the root lice have done the greater part of the mischief in the States beyond the Mississippi; but in Illinois the only considerable injury seen by us in 1898 and 1899 was that done by the pale-striped flea-beetles, the grasshoppers, and the blister beetles.

Insect injuries to the underground part of the beet commonly take the form of a cutting of the taproot, an eating away of the smaller roots, or a burrowing or excavation of the mass of the beet itself. They are commonly due to wireworms, to white grubs, or to the beetles of one of the muckworms (*Ligyrus gibbosus*). More rarely root lice seriously damage the plant in summer by sucking the sap from the roots. It is probable that larvæ of some of the flea-beetles will also be found to infest the plant underground.

Injuries to the leaf may be done either by bugs with a sucking beak, or by beetles, grasshoppers, or insect larvæ, with biting mouths. The former abstract the sap from the stem or the blade of the leaf, often making discolored spots, dwarfing the growth and causing the leaf to curl, or even killing it completely. Beetles and their larvæ, caterpillars, grasshoppers and the like commonly make holes in the leaf, the smaller insects small circular holes, as a rule, and the larger ones either gnawing away the edge of the leaf, eating out irregular holes, or (if cutworms) cutting off the stalk near the ground. Small holes made in the young growing blade may greatly enlarge as the plant expands, becoming longest in the direction of the most rapid growth. Certain maggots of flies (the leaf miners) eat out the interior substance of the leaf in patches, leaving the cuticle unbroken.

The first injury to the beet reported in America was a mining of the leaves by the maggots of certain flies in a New York vegetable garden, an injury sufficient to prevent the use of the leaves for "greens." Later, serious and extensive damage was done by these leaf miners to fields of sugar beets in California. The leaf is penetrated by the insects, and the tissue is eaten out between the upper and lower layers of the cuticle, colorless, blister-like spots being thus produced.

Perhaps the most destructive of the beet insects in the West are the garden webworms (*Loxostege similalis* and *L. sticticalis*). The latter was in 1892 the chief depredator in the beet fields of Grand Island, Platte Center, and several other Nebraska localities, where many of the plants were entirely defoliated.

The garden Mamestra (*Mamestra trifolii*), a caterpillar allied to the zebra caterpillar of the cabbage, has been reported, by Prof. Lawrence Bruner, of Nebraska, to be quite common in that State and sometimes considerably injurious to the beet.

Cutworms have been noticed wherever beets are raised. Bruner reports them in 1891 as occasionally quite destructive to the plant while it is small, continuing their injury more or less throughout the summer. They commonly cut off the leaf at or

a little below the surface of the ground, but some of them merely feed upon the blades. In 1892 they almost entirely destroyed sugar beets growing upon two experiment-station plats at Lincoln, Nebr., on one of which only about 20 per cent of a stand was obtained. It was noticed here that little injury was done on land plowed the preceding fall and a second time in spring. Osborn noticed cutworms in Iowa doing serious injury to young beets in 1891.

The Beet Army Worm.

The State agricultural experiment station of Colorado published a bulletin on this subject, prepared by Prof. Clarence P. Gillette, the entomologist. On account of Professor Gillette's standing as an authority on entomological subjects, the article is reproduced here as being very pertinent matter for study by those interested in the growing of sugar beets.

LIFE HABITS.

The caterpiller which did so much injury to sugar beets in the vicinity of Grand Junction last year will doubtless appear again this summer. While the insect has long been known to entomologists, last year was the first that it has been reported doing serious harm to any crop.

While the life habits of the insect have never been studied, it seems probable, from what the writer could learn of it last summer and fall, that it has two broods in the course of a year. The caterpillars that were so abundant during August last year entered the ground and then appeared again as moths in September. There were few enemies to destroy the caterpillars, and the moths hatched in enormous numbers. These moths, like house flies and mosquitoes, seek every available place of protection from winter's storm and cold that they may live (hibernate) until spring. When vegetation starts, the moths, laden with eggs, go in search of beets or other plants furnishing suitable food, to deposit their eggs and thus provide for an early brood of worms. If 10 per cent of the fall brood of moths survive the winter, there is serious danger that beets will fare worse this summer than they did last, unless growers are early on their guard to make thorough and timely application of effectual remedies. Just here let me warn all against experimenting with new or patent remedies which some friend or vender may think entirely satisfactory. Use such remedies very cautiously and sparingly at first, or do not use them at all.

From what could be gathered last summer, it seems that there was a first brood of caterpillars at about the time for thinning the beets, which, in some cases, destroyed most of the plants after thinning.

REMEDIES.

Experiments tried last summer proved that the common poisons, paris green, London purple, and white arsenic, will destroy the caterpillars if well distributed upon the beets. These poisons may be applied dry or in water. If the caterpillars appear upon the beets while the latter are small, I believe the best method of application is to mix 1 part by weight of paris green or London purple with 20 parts of common flour, and then dust the mixture over the plants before sunrise in the morning. In this strength a light dusting will be sufficient. The early application is recommended because then the leaves have a slight amount of moisture upon them, which helps to hold the flour and poison. Just after the leaves are moistened by a shower is also a good time to make the application.

To apply the poison, make a small cheese-cloth sack about 5 inches in diameter and 10 inches deep; fill it with the mixture of poison and flour, and walk along a row of plants, shaking the sack over them. This can be done quite rapidly when

one has learned how, is economical of poison, and does not require wheelbarrow or wagon to carry pump and tank.

When the plants become large, as in case of treatment for the second brood, it will probably be better to use a barrel or tank and spray pump.

If a spray is used, apply either paris green or London purple in the proportion of a pound to 100 gallons of water, and add 2 pounds of fresh lime for each pound of poison. The lime should be slaked and strained through a sack to take out lumps; then use a nozzle that throws a fine spray, and do not continue the application in any place long enough so that the drops sprayed upon the leaves will run together and flow off, carrying the poison with them.

If white arsenic is used, prepare according to the following directions:

Put 2 pounds of white arsenic and 8 pounds of sal soda together in a dish and boil for twenty minutes in 2 gallons of water, and keep as a concentrated solution. It is extremely poisonous and should be placed at once where there is no possibility that children or domestic animals can get it. Also label it "poison" in large letters.

Then, in each 40 gallons of water, first slake 4 pounds of lime and then add slowly 1 quart of the concentrated solution while the whole is being stirred. The mixture is then ready for application, as in case of paris green. The lime should be strained through a cloth to take out the lumps.

I am advising the use of these poisons somewhat stronger than is common, but the experience of last year makes it seem advisable to do so.

Growers should keep the closest watch of their beets this year in order not to let the caterpillars get the start of them. I hope to be notified of any appearance of these worms or other injurious insects promptly, and shall be glad to do all in my power to aid those who are anxious to save their crops from the attacks of such pests.

EXPERIMENTS IN EXTERMINATING THE ARMY WORM.

In connection with what Professor Gillette has said above, I insert the following report made by him in the July number of the Beet Sugar Gazette, of Chicago, showing the success of his recommendations and what can be accomplished by vigilance and industry:

In the light of the trouble we had last year in this locality with the fall army worm, and which afterwards became known as the "sugar-beet worm," it may be of interest to you and to all sugar-beet raisers to know that we found a very simple remedy for it last year, and that we have no appearance of its return at this time. The remedy was in saturating the ground with water, killing the pupa, which enters the ground after each successive visitation of the worms, and there hatches out into the moth, which deposits the eggs for the next brood. It was discovered that on the fields where irrigation was in progress when the first brood made its appearance there was no second brood, and, following this up, we had the ground very thoroughly irrigated after the second brood, which seems to have entirely drowned out the pupæ, and this year there is no probability that we will be bothered with them.

As this pest was a serious matter with us last year, and as we learn it has made a visitation to other beet-raising districts, we felt that this news should be circulated as widely as possible, and in irrigated districts particularly it would be very easy to follow up our methods. In the rain districts we would expect the heavy rains to accomplish the same result.

We also found that the worms were very easily killed with paris green, as their work is entirely on the upper surface of the leaves during all the early stages, and only in the worst, or advanced, stages did they attempt to work at the base of the leaves or in the crown of the beet. One matter which facilitated the killing of these worms was the discovery that the beet plant was not easily injured by arsenical poisons, and that the strength which would be injurious to tree foliage and much other vegetation has no effect whatever upon the beet leaves. We used it in some

instances to the extent of 2 pounds to the barrel, with the addition of from 1 to 2 pounds of lime to each quarter pound of the arsenic or paris green, and the leaves seemed to be in just as good shape after its application. We found that half a pound to the barrel, thoroughly applied, was sufficient to kill the worm by simply spraying over the fields.

REPORTS OF MANAGERS OF FACTORIES.

At the time I sent out letters to experiment-station workers I also sent out letters to managers of factories, calling for specific data covering the experience of these factory districts during the season with diseases and insects affecting the beets.

It appears that the manufacturers had been early aroused to the importance of the situation, and, in their replies, were able to furnish some very valuable information, covering not only a description of the symptoms, but much scientific information bearing on the subject. They called to their aid the best scientific assistance they could secure to solve the problems before them. Much of the results is speculative, but throughout these reports are many important facts that will aid the sugar-beet grower in the future in classifying the beet enemies he has to contend with and applying remedies.

The reports of the managers of these factories follow:

Beet Root Blight in California.

Alameda Sugar Company,
San Francisco, Cal., October 3, 1900.

The following is submitted in reply to yours of September 24, 1900:

In 1899 the fields of the Union Sugar Company were badly affected by this disease, and much time and money were expended to determine the cause, and, if possible, the remedy. Our bacteriologist isolated the bacillus and determined it to be *Bacteriose gummosis*. The same disease was first noticed in 1890, and more particularly described by Sorauer, in 1893, and by A. Stift, of Vienna, in 1899. Of the agent in causing the disease there can be no doubt, but here our knowledge ends and speculation begins.

In Europe where the disease has caused as widespread injury as in the United States it has been attributed to drought, but from the writer's observation this can not be the cause in all cases, for in this State on the farms of the Spreckels Sugar Company this year, the land was well irrigated and yet the blight destroyed the entire crop. In Pajaro Valley the rainfall was about 30 inches, but disease has so affected the crop as to reduce it to about one-third.

This year the fields of the Union Sugar Company were not materially affected by bacteriosis, although it was present in isolated cases, and yet on unirrigated lands, although the drought has greatly diminished the yield, there was no spreading of the disease. On irrigated lands there were also isolated cases of bacteriosis, but they were insignificant.

On lands tributary to the Alameda Sugar Company there was no observation of the disease in 1899, but in 1900 the beet area was affected with it to a limited extent, say 2 per cent of the whole acreage, and this in but one or two fields.

Many have attributed the cause to bacteria occurring in the seed used, but the seed used by both the Alameda and Union Sugar companies in 1899 and 1900 was of the same importation as that sown for the Alameda Company in 1898, and the disease was not then noticed in this State. But to determine this question we had cultures made from the seed both from the surface and germ, and from all the varieties used without results.

Cultures were also made of the soil from samples taken to the depth of 2 feet, but although the cultures were prolific in life forms, none like *Bacteriose gummosis* could be isolated. These cultures can not, however, be regarded as conclusive for the reason that the samples were taken in the month of December, quite long after the beets were harvested and after rains had fallen. The depth to which the soil sample was taken may also have been of importance. From the fact that potatoes, tomatoes, squashes, and other vegetables have been materially injured by the same or a similar disease in various localities in California, it would seem that the bacteria might be in the soil notwithstanding.

Several test experiments were made on plots of land far removed from the beet fields, as follows:

1. Beet seed was sown in April, 1900, and after thinning, carefully examined at various times, bacteriologically, without result.

2. Young plants from disease-free fields were transplanted to this plot for observation. They remained free from disease.

3. Young beets from diseased fields were also transplanted and studied. Every care was given in the way of cultivation and moisture to see if the beets would recover. They did not recover.

4. Healthy beets from the previous year were inoculated from cultures of *Bacteriose gummosis*, but without success.

5. Healthy beets from this year's planting were inoculated with cultures of *Bacteriose gummosis* from affected beets from Los Alamos, Kings City, and Santa Maria, but the results were not definite. A fourth beet was inoculated with *Bacteriose fluorescens* without result.

A. Stift, of Vienna, previously mentioned, claims to have succeeded in inoculating healthy beets with the virus of this disease, but all attempts in this direction by our bacteriologist were unsatisfactory.

Comparative cultures from diseased beets of 1899 and 1900 showed that the bacteria of 1900 were less numerous and more attenuated than those from 1899.

Opinions have been expressed locally that the lack of moisture in the soil, at depths of 2 feet and more, has much to do with the unhealthy condition of the plant, and that when the soil is restored to its normal conditions by ample rainfall there will be no further trouble.

Certain it is that in one examination made by digging alongside a row of beets and following the roots down to their utmost limit, blight was found only in those beets which reached the dry subsoil, whereas those roots which had not yet penetrated the moist layer, showed no signs of blight. As this was an isolated case, perhaps no conclusions should be drawn from it, especially as in other localities roots still in moist soil showed the disease.

In general among those connected with the industry with whom the writter has conversed, the opinion prevails that thus far but little progress has been made in acquiring knowledge of the cause of the disease or in devising methods to combat it.

Yours, very truly,

ALAMEDA SUGAR COMPANY and
UNION SUGAR COMPANY,
By E. C. BURR, *Manager.*

AMERICAN BEET SUGAR COMPANY,
Chino, Cal., October 1, 1900.

We beg to acknowledge yours of the 24th ultimo, and in reply we beg to say that the root blight of which you speak has not appeared at this place. The blight which has affected our beets is not apparently in any way a rot, as the beets remain perfectly

sound. The leaves curl up and wilt, the growth of the beet is apparently arrested, and it throws out innumerable very small rootlets, sometimes almost entirely covering one side of the beet, so that, when it is taken from the ground, the body is very small, with a large mass of roots. We can not give any cause for the blight, as the various parties who have made investigations apparently do not agree. Some think it due to climatic conditions, some to a fungous growth, and others to bacteria. The blight usually does not develop until the beets have taken two or three months' growth.

Yours, truly,

AMERICAN BEET SUGAR COMPANY,
Per ANDERSON.

LOS ALAMITOS SUGAR COMPANY,
Los Alamitos, Cal., January 10, 1901.

There was very little rainfall for the season 1900, also for the two preceding seasons, so that there was very little moisture in the subsoil and for many feet below.

In regard to root blight it first appeared about the 1st of June. There had been no rain for nearly a month. On the driest light sandy soil the beet ceased growing, turned yellow; small leaves in the center of crown turned black and a gummy substance exuded. There was no rot; the beet began drying up though still showing signs of life; the fiber turned black, showing rings of blackness, and the beet was almost entirely covered with small fine roots. Beets on moist land were not affected. It was the fourth year of planting on this land, no beets having been harvested the two preceding years. The crop was badly damaged in sections of four different contiguous fields. Drought is the only cause I am able to suggest. There was only one disease here.

LOS ALAMITOS SUGAR COMPANY.

CALIFORNIA AND HAWAIIAN SUGAR REFINING COMPANY,
Crockett, Cal., February 28, 1901.

In response to yours of recent date, we send you reports from the managers of a number of our large beet farms.

(Signed) CALIFORNIA AND HAWAIIAN SUGAR REFINING CO.

Concord district, Contra Costa County.

Soil.—I am working all kinds of alluvial land, both light and dark sediment land, sediment and adobe mixed, alkali, and adobe. Practically all of this land has a heavy adobe subsoil, which is very cold.

Climate.—Our season's rainfall was about 15.75 inches, commencing in November, 1899, and stopping with light storms in March. Of this we had 11 inches previous to the 5th of January. Our season was therefore mostly free from spring rains, which we must depend on here to carry us through a long dry summer. During December and January we had six or seven weeks of foggy weather, during which we had numerous light rains, which kept the surface of our land wet, prevented plowing most of the time, and caused a rank growth of natural vegetation, which naturally dries out the land very fast.

Our winter was remarkably free from frost, with a good deal of damp weather; the ground was wet to a depth of from 4 to 5 feet. Most of our plowing was done after February 1, 1900, which was too late in the season for good results.

Results and observations.—On 100 acres of very heavy land, which I had plowed deep during June, 1898, for beet summer fallow, we had a good crop of beets, which

were in splendid shape, and were clean and free from rootlets, of good color and crisp; we had similar results on another field where the ground was lighter, being low and having a better supply of moisture, also having been worked early in the season, but plowed rather shallow. The above results were secured even where we had to plow under a heavy growth of grass late in the season, thus losing considerable moisture.

Aside from the above-mentioned fields, we had mostly a light crop of beets on all lands alike, most of the land having been plowed during late winter or early spring, and being new beet land it broke up cloddy. The season was such that the land did not slack, owing to the absence of frost and sun, and was only reduced to a seed bed by much harrowing, smoothing, etc., which packed the land too solid, though a good stand of thrifty beets was secured. They stopped growing entirely about the middle of June, when the hot weather came on, and the greater part of them burned later in the season. Examination at this time showed that the beets were covered from the crown down on the root with a network of fibrous rootlets. I think the trouble with our beet crop in this valley the present year was caused by lack of frost and sun during winter to slacken the clods and liberate the acid from the soil; and also, lack of moisture to sustain the beets when the warm weather came; thus the fungus attacked the beets and checked the growth.

The failure of our beet crop by what is known as "blight" is, I think, the result of a combination of conditions, namely: The acid in our soil causing the fungus in hot weather, which attacks the root of the beet; at the same time there was a shortage of moisture, and the beet plant was not in a vigorous condition to withstand attack.

I do not expect to see so-called blight next year.

Yours, respectfully,

R. N. BURGESS,
Manager Hookston Sugar-Beet Farm.

Report from K. G. Raaf, Sonoma County.

Replying to your inquiry in regard to beet diseases, I will say that at this location the soil is sedimentary, composed of sand, clay, and decayed vegetable matters, and has been reclaimed from the waters of the bay about ten years. Last year the land was plowed and planted to beets for the first time, with the exception of three small trial patches planted three years ago, which turned out beets fine in quantity and quality, and apparently free from all diseases. Last year something affected the beets which I never saw before, although I have been raising beets for the last nineteen years in almost all sorts of soils and climate. I am acquainted with the common diseases and insects that attack the beets, but have never seen anything like what appeared last season and what has been called "blight." It appeared only in patches here, and earlier beets were attacked more than the later planting; those planted in May were nearly free from the trouble, but I noticed that it was the opposite of other places.

I have some beets now growing that came up in the month of November which are from one-half to 1 inch in diameter, and they have a healthy appearance, the roots being free from the disease. It is my idea that something attacked the beet at the germination of the seed, because as soon as the two leaves were formed we noticed something wrong. After the plant formed four to six leaves they were of a light color, and on pulling up the root it was found that the small fibers lengthwise of the beet were dark in color; but the beet continued growing some until a fibrous, hairy growth appeared on the outside; then the plant seemed to stop growing, but neither decaying nor dying, as the climate here is favorable to growth.

The center leaves would drop off while new ones came on, the root getting hard and woody after two months. What the cause of this is I do not know, but as you ask for opinions I will state that I believe it is of a fungous origin, that conditions

probably were favorable for its growth, and that it is like the fungi that appear on other plants when conditions are favorable for the same.

Shall be pleased to find out something definite about this disease and what is the cause of its appearance. It was such a destructive agent among the beet growers of this State that no effort should be spared to find out what it is, and the proper remedy for the same. I saw land irrigated, land not irrigated, sandy loam, and adobe, but this disease seemed to get in its work everywhere.

Yours, truly,

K. G. RAAF,
In charge of Beet Farm at Reclamation.

Suisun district, Solano County.

In replying to your request for information regarding the sugar-beet crop, conditions of soil, etc., for the year 1900, I will say the season was very unsatisfactory in this locality, owing to the limited rainfall—which was only about 17 inches for the season, a greater part of which fell prior to February 16, and which was barely two-thirds the usual amount for this section—and also to the entire absence of the necessary spring rains.

The greater part of our land having never been plowed deep before, the proper seed bed could not be prepared in time, as we were unable to work the land until February. Our land is principally adobe, with the exception of about 200 acres of sandy sediment from which we harvested our best beets, this land being the best prepared and earliest planted.

We began seeding about the middle of February, finishing early in May, seeding in all about 1,000 acres. Owing to the late seeding and lack of moisture, there were several hundred acres upon which we failed to get a stand. We had a fair average stand on about 800 acres, which grew well until about the middle of July, when they began to dry in patches, the leaves shriveled, turned yellow, and the beet shrunk and died. In other places the leaves turned black and appeared as if they had been scorched by fire. They were very brittle and would crumble when touched, but the beet did not show any damage.

We began cultivating when the plants were about 3 inches high, and continued until they were too large for the cultivator to pass between the rows.

——— ———.

Cordelia district, Solano County.

In replying to your questions as to conditions of beet crop for year 1900, I will state that the season was a most unsatisfactory one for beet farming, and under the conditions prevailing I am not at all surprised at the results. We had in all about 17 inches of rain, and, falling the way it did, this is a small amount for this locality, the two previous seasons being dry. Almost all of the rain fell before the middle of February, so we had no late spring rains, without which in this location the beet crop is almost sure to be a failure. The season was free from frosts, with continual fogs during the months of January and February. The weather, being warm, caused a great deal of vegetation to grow upon the land. The land, being a heavy soil mixed with more or less adobe and alkali streaks, is hard to work and prepare in proper shape for beets. Under the conditions prevailing, we were unable to commence plowing the land until the 15th of January, which is very late. The most of this land was never worked for beets before. The fogs prevailing at the time kept the land wet and moist, preventing harrowing and working otherwise.

Commenced planting on 20th of March, finished on 28th of April, having seeded about 750 acres. Had a good average stand on about 400 acres. The balance of seed planted failed to come up with exception of patches. We had about 1 inch of rain shortly after commencing to plant seed. The beets were well cultivated, and

on 400 acres looked well and thrifty until early in July, when they seemed to stop growing, and in patches seemed to be affected with blight. The leaves commenced to turn yellow and die. The weather all along up to this time had been cool. After a short warm spell it turned cool again. Then the beets already turned yellow began to look green once more and, I think, commenced to grow again. Later on I noticed something different, but only odd beets, some on high land, but I think a bigger percentage of those were on low alkali lands. Attention was drawn to these beets by their leaves being dead, and on pulling the beets they would be black and covered with a fungous growth, the dirt adhering to the beet. It is my judgment those beets were attacked by some insects. While thinning I noticed some plants affected in the same manner.

J. SMITH,
Foreman Cordelia District, Solano County, Cal.

Report from New Hope district.

The disturbance appeared about the middle of June. At that time the weather was unusually hot, with almost continual high, hot north winds. Between the first and middle of June there were three very hot days. The first thing noticed was the leaves turning yellowish and curling up. Later on the outside leaves dried up and fell off. The center leaves started out again and looked to be healthy, but somewhat smaller. Some plants were affected more than others. Ones that were most affected did not grow after the leaves curled. The beets that were planted early were not affected so much as the late ones. The upper part of the beet root did not seem to be affected so much with the small fibrous roots as did the body of the beet.

There was plenty of moisture all this time, and when a beet was pulled the soil would adhere to the small fibrous roots in a large quantity and it was full of moisture. The early prospects were that from 10 to 15 tons per acre would be harvested, but owing to this blight only about 2 tons per acre were harvested on an average. Beets that were most affected with the small fibrous roots, when cut open, were of a darker color than those that were not. In my opinion the cause was too much early hot weather, with too much wind, which kept the dews from falling, and at the same time kept the tops of the beets continually moving night and day.

I noticed in the bottom of the sloughs that the beets were not near so much affected where they were protected from the wind.

D. L. SMITH,
Foreman of Beet Ranch at New Hope, San Joaquin County, Cal.

DISEASES OF SUGAR BEETS IN COLORADO.

AMERICAN BEET SUGAR COMPANY,
Rockyford, Colo., October 1, 1900.

We beg to acknowledge receipt of your favor of the 24th instant, and wish to say in reply that the root blight of sugar beets has appeared in the district of the Rockyford factory to such a small degree and so sporadically that no definite conclusion as to the cause of the disease can be drawn. The acreage for the Rockyford factory is spread over the territory from Pueblo, Colo., to Holly, Colo.

In explanation, we wish to say that affected beets are found on light and heavy soil; on land which has been irrigated three times, as well as on land which was not irrigated, and the diseased beets showed up in early as well as in late plantings. The disease developed only to such a small degree that the few blighted beets would never have been detected had not a very careful search been made for them after we received notice of the appearance of the disease in California.

During the last three weeks blighted beets have practically disappeared, so that

fields which showed a few diseased beets four or five weeks ago, at the time when the weather was very hot, are now, so to say, free from blight.

As to the point whether the land upon which a crop of beets has been blighted one year will transmit the same trouble to a succeeding crop of beets, we can not give data, as beets on a large scale for manufacturing purposes are grown this season for the first time in this locality.

Very truly, yours,

AMERICAN BEET SUGAR CO.,
Per WIETZER, *Manager.*

EXPÉRIENCE WITH BEET DISEASES IN ILLINOIS.

ILLINOIS SUGAR REFINING COMPANY,
Pekin, Ill., October 6, 1900.

Your letter of some days since to the Illinois Sugar Refining Company, relative to the root blight of beets, has been placed in my hands. In reply will say that in some of our fields, where the soil is strong, and especially where the dirt was thrown up into the crown of the beets, there has been some loss from rot; however, it has always appeared first at the crown of the beet and worked downward. In most of our fields there has been no loss whatever from this rot and in the fields most affected the damage would not exceed 6 or 8 per cent at the outside.

We have been troubled some, especially in localities where beets were grown last year, with leaf rust or blight. This appeared in places in our fields about September 1 and the leaves all died down in the spots or fields affected; however, most of the beets have sent out new leaves and the fields are as green as at any time during the growing season.

We will be only too glad to cooperate with you in any way possible and we take pleasure in sending you samples of the affected beets.

Very respectfully,

P. G. HOLDEN,
Superintendent Agricultural Department.

REPORT OF A MINNESOTA FACTORY.

MINNESOTA SUGAR COMPANY,
St. Louis Park, Minn., September 27, 1900.

Replying to your valued favor of September 24, we are pleased to state that as far as we have been able to ascertain, the root blight has not been noticed by our agriculturists and farmers in any of the territories where the sugar beets have been cultivated for us. In a few cases the leaf blight was noticed, but without any serious effect. The writer has found a solution of xanthoginate of sodium or potassium (the sulpho-carbon double salt), an effective remedy for the leaf blight.

Respectfully,

F. W. FINK, *General Manager.*

JANUARY 23, 1901.

Your esteemed favor of December 24 was forwarded to my present address, where I am staying for a while to attend to some business and private matters.

Inclosed please find answers to your list of interrogations, and also some remarks on last season, to which I refer.

In regard to diseases affecting the beet plant, which have been prevalent in other parts of the United States and in European countries, I am glad to state that our section has been spared, with the exception of some leaf blight in a mild degree, of which I spoke in a previous communication, and which occurred in a few fields only, without doing any damage to the crop. It was noticed only in a single instance that

a portion of 1 carload of beets out of about 25 carloads from the same farm (that of Thomas Lowry, Montgomery, Minn.) was affected by a fungous growth of a brown, woody, fibrous character. As nearly as I could ascertain, these diseased beets were the product of a small patch of which evidently the soil contained the origin of the fungus. All the rest of the beet field (about 25 acres) was not affected, but remained in a healthy condition.

Respectfully, F. W. FINK.

VIEWS OF MICHIGAN MANUFACTURERS.

KALAMAZOO BEET SUGAR COMPANY,
Kalamazoo, Mich., January 15, 1901.

The secretary of our company (Kalamazoo Beet Sugar Company) forwarded me your letter of inquiry of Decemder 27, 1900. I will answer you to the best of my ability and knowledge.

The so-called "root blight," or "root rot" I would define as three distinct diseases, and possibly four, which are caused by conditions of soil and climate and the work of insects.

The first will be noticed in one or two weeks after plants come up; the bark of the root will turn black, and if unfavorable conditions continue it will rot the heart of the plant. It is caused by excessive wet and by ground becoming heated. It can in almost all cases be cured by thorough cultivation, airing the soil, unless wet weather continues. We lost about 4 per cent from this cause.

The next condition in this line appeared about July 1. We would notice a plant here and there decayed in the root and such a plant would soon die, and sometimes several around it would die; on examination I found small white worms in those roots, whether the affection was caused by the worms and whether it was contagious are questions I am not able to answer, nor am I able to prescribe any cure. We lost possibly one-half per cent from this cause.

About July 15 the leaf spot begun to appear on the leaves, small brown spots with darker margins and sometimes the edges of leaves would turn black and roll up dry. The disease would grow down from leaves to the root, making a fungous-rib growth around the crown of beet, with sometimes spots appearing lower down on the root. It would stop the growth of the root, and affected beets showed a low percentage of sugar. The only remedy I found that would do any good was the Bordeaux mixture. We lost probably 3 per cent from this cause.

The last half of July and first part of August we experienced wet weather in part of our territory, and, where drainage was poor, the ground was so heated and became so wet that it scalded the roots, retarding the growth and in extreme cases rotting the root. The leaf spot I think is caused by the conditions of the soil, partly drainage, and partly from ingredients of soil. Hoping you will find this information satisfactory,

I am, yours, truly, C. S. BENDER,
Agriculturist for the Kalamazoo Beet Sugar Company.

ALMA SUGAR COMPANY,
Alma, Mich., September 26, 1900.

Replying to yours of the 24th instant, I will say that we have not as yet had any experience with the root blight to which you refer; consequently we can not give you any information bearing on the subject.

Yours, respectfully, ALMA SUGAR CO.,
Per F. R. HATHAWAY,
General Manager.

HOLLAND SUGAR COMPANY,
Holland, Mich., September 26, 1900.

DEAR SIR: Referring to your favor of September 24, we will say that we have examined our beet fields somewhat during the latter part of the summer for this root blight and have found but little of it. A large percentage of our beets have been sown this year on low land, and we have had a very wet season, so that there is considerable rot on this lowest land, but it does not affect the beet in the same way as this root blight seems to, so we call it simply ordinary rot. What root blight we have found has been largely on the higher land, and especially on the light gravelly soil. We have had, however, a few cases on the lower land. Some places where it has started on the row it seems to follow right along, taking every beet. We have sent some samples to Washington for analysis, and will gladly furnish samples to our own experiment station at Lansing. The blight does not seem to be at all serious in this section.

Very respectfully,

HOLLAND SUGAR CO.,
C. M. MCLEAN, *Manager.*
Per S.

JANUARY 29, 1901.

Our beets this past season were damaged very little by any disease. There was only here and there a field in which we found anything that might come under the head of "beet blight," and no field was seriously injured. The traces we found in nearly every case were on high ground, usually in poor soil. Here in an advanced case the leaves would be entirely gone save for a dark mark on the ground where they had lain; the root would retain nearly or quite its full size, but would have left only what might be called the fibrous framework, dry, brownish in color, brittle, and, of course, entirely lifeless. In some instances the disease would appear to follow up the row from beet to beet, taking every root for several rods.

We regret that we can not give you more specific data.

Yours, very respectfully,

HOLLAND SUGAR CO.,
C. M. MCLEAN, *Manager.*

THE WOLVERINE SUGAR COMPANY,
Benton Harbor, Mich., September 26, 1900.

DEAR SIR: We have received yours of 24th, and in reply will say that we experienced a difficulty in our beet patches this year which corresponds in most important particulars to the ones you describe in your letter. In fact, it is so prevalent in our territory that it is hard to find any patches that are not more or less affected.

The principal difference between the trouble as it has appeared with us and your description seems to be that we do not find the roots affected by any apparent disease. The whole exhibition of abnormal appearance seems, so far as we are able to judge, to be in top or leaves.

I send you by this mail a number of the leaves as they appear at different stages during the progress of the difficulty. It appeared first about the last of July or first of August and on the patches that were growing on the lowest ground, and has gradually increased until, as I said before, there are very few of our patches that are not more or less affected.

We were at first inclined to think that it was caused by very heavy rains, followed by very hot sunshine before the patch had any time to dry off, and it is still undoubtedly true that the low patches that were subject to these conditions are the ones that were affected the worst.

The difficulty, however, varies from your description in the fact that there seems to be practically no rotting at the root. Beets that have been affected with this difficulty for two months, when pulled from the ground and the tops cut off are apparently as healthy and good-looking beets as we had last year. They are, however, abnormally low in polarization, showing a sugar percentage in the juice of between 11 and 12; the factor is apparently very high, showing in two series of tests within the last two days of 94 and 95 and 96 and 97, respectively.

When the difficulty has reached its ultimate conclusion, in such cases, where there has been no new growth of leaves, the beet when pulled up looks like one that has been allowed to lie two or three weeks and become very much dried up. There is in quite a number of the specimens which we have tested recently a large amount of invert sugar, amounting in some cases to nearly 4 per cent. We are unable to say that this difficulty has appeared with more frequency on fields where beets were grown last year, having appeared first on a field where there were no beets last year, but where the ground was very low, and where the conditions described before in this letter prevailed to a large extent. In another instance, where we have a piece of 154 acres, 100 of which was in beets last year, the disease appeared first, and just as badly on the new part, but extended at once and very rapidly to all parts of the field. This latter piece, upon which it is impossible to find a single beet which is not affected, does not show the slightest appearance of any abnormal condition of the root, but they only test about 9 per cent in the juice, and do not seem to have gained anything in sugar in the last three weeks. They have gained in appearance, the tops growing larger until at the present time each beet has probably 8 or 10 green leaves. These leaves are healthy, but are small. The crown of the beet during the progress of the difficulty becomes very much elongated until in some instances the crown will compose nearly one-half of the beet. We have supposed that this condition was caused by the continuous growth of new leaves.

You will of course notice the characteristic spotted appearance which shows itself on every one of the beets more or less affected.

In a general way, our opinion would be that the earlier planted pieces are affected the worst. This covers all that our observation has enabled us to learn. If there are any questions aside from this that you would like to ask, please do so without hesitation, as we should be very glad to act in conjunction with you, and also with the various experiment stations, just as far as we can.

Yours, very truly,

THE WOLVERINE SUGAR CO.,
H. C. ROCKWELL, *Secretary.*

TROUBLE IN NEBRASKA.

STANDARD BEET SUGAR COMPANY,
Ames, Nebr., September 26, 1900.

Your valued favor of the 24th instant is duly received.

We have had a good deal of trouble with root blight in our beet crop this season, it being our first experience with the disease, and there are naturally a good many different opinions among beet growers as to its cause, etc. The disease in our fields was first noticed during the latter part of July, our attention being attracted by the leaves of plants that were apparently healthy falling down flat on the ground, and the plant afterwards sending out little curly leaves. On pulling beets affected in this way and cutting them open it was found that there were dark rings all through the root, which seemed to be brittle and woody. A small percentage of beets was affected in this way at the time, but it seemed to gradually spread throughout the early part of August, and leaf spot also made its appearance in a great many of the fields at the same time. During the latter part of August a good many fields of early-planted

beets were quite badly affected with leaf spot, and at this time we had a period of extremely hot damp weather, and the foliage of the beets on fields affected as above described turned black and died, leaving the leaf stems standing. In most of the fields affected in this way a large percentage of the beets put out new and natural leaves, while a small percentage of the balance sent up the curly leaf, indicating the root rot, and the remainder developed the crown rot, the leaf stems turning black and rotting down to the beet, which in turn became affected. Our loss in tonnage from this cause, however, is not heavy—in fact, we hardly think our total loss of tonnage from root rot, leaf spot, etc., will be as high as 10 per cent.

Since the 1st of September we have had heavy and frequent rains, with cooler weather, and the crop has wonderfully recuperated. Plants that lost their foliage and were not affected with the root rot have grown new tops and are gradually coming up in sugar, while some that are affected have sent out side rootlets that are keeping the beet alive, though the point of the tap root has decayed, but the sugar content of such beets is in every case low.

The consensus of opinion here seems to be that the very hot damp weather, coming at a time when beets had been suffering for moisture, was largely responsible for the trouble. Since the weather has turned cooler it has stopped the spread of both leaf spot and root rot, which we consider two separate diseases. We have experimented largely with Bordeaux mixture to prevent the spread of leaf spot, but with very little apparent success, and we have concluded that rotation of crops is the best kind of a preventive, using lime as a fertilizer wherever practicable.

While leaf spot, according to the best authorities, can be transmitted to a crop of the same family, following a beet crop that is affected with it, yet we have concluded that it is largely caused by the climatic conditions, as we have had fields affected with it this year that were at least 50 miles from any point where sugar beets had been grown before.

We will be very glad to cooperate in every way we can with the State experiment station in any investigations they may wish to make.

Yours, very truly,

STANDARD BEET SUGAR CO.,
Per H. SCILLEY.

JANUARY 9, 1901.

Referring to the matter of diseases of beets, I am satisfied that we had three distinct diseases here last season, which I would class as follows:

(1) Crown rot, which always exists to a limited extent, and with which we are all familiar. We can control this by pulling and burning or destroying any beets we find affected, thus preventing the spread of the disease.

(2) Leaf blight, called by botanists "Phyllosticta."

(3) Leaf spot, called by botanists "Cercospora."

The leaf blight and leaf spot first made their appearance in our fields during the latter part of July, after an extended dry hot period, followed by moderately heavy rains.

LEAF BLIGHT.

Our attention was first called to the "leaf blight" by the leaves wilting, falling flat on the ground and dying, the beet afterwards in some cases sending up little curly leaves, which we found indicated an unhealthy condition of the root. On cutting such beets open we found dark circular rings all through them; they were also brittle and contained much less juice than those that were not affected. In some cases the leaves came out in their natural shape again, but in growing the new leaves the crown became elongated, and in a great many cases hollow. In other instances the crown

rot developed, causing considerable loss, and almost every field affected failed to develop a satisfactory sugar content.

We believe that the disease developed on account of the growth of the beet being seriously checked by the dry hot weather before referred to, causing the beets to start to ripen prematurely; then when the moisture came they started a new growth. The weather at this time was extremely hot, and the disease developed in about three days. Its rapid development was doubtless materially aided by the physical condition of the soil, which owing to wet weather during the preparation of the seed bed was in a great many cases improperly pulverized and packed.

Another reason why we take the above position as to the cause of the disease is that late-planted beets that had not reached such an advanced stage of growth were not affected at all, though in a great many instances they were in the same field as those that were.

LEAF SPOT.

Leaf spot is a fungous disease often described in experiment station bulletins, and appeared in our fields as above stated, about the same time as the leaf blight. It started in some fields where beets had been grown the previous year and had been affected with the same disase. This first appeared in little brown spots on the leaves, which quickly spread, killing the leaves, and causing the beet to devote its whole efforts to the growth of new leaves. The fresh leaves in turn became affected, the result being long, hollow crowns, small roots and a poor sugar content. The disease after first making its appearance spread very rapidly, until the greater part of our acreage was more or less affected. We tried to prevent its spread by spraying with Bordeaux mixture, but without much apparent success.

It is pretty hard to estimate the damage to the crop, but in a rough way I should say that we suffered a loss of 15 per cent in tonnage and 3½ per cent in sugar content.

We attribute the cause of leaf spot largely to the fact that beets were planted a second time on the same land, the first crop having been affected with the leaf spot, and the germs or spores having lived over in the ground. We also think the climatic conditions were very favorable to its development. In some cases we thought it might be introduced in the seed, as it made its appearance in isolated districts where a beet crop had not been grown before.

Yours, very truly,

STANDARD BEET SUGAR CO.,
Per H. SCILLEY, *Agriculturist.*

AMERICAN BEET SUGAR COMPANY,
Grand Island, Nebr., January 12, 1901.

DEAR SIR: Your favors of September 24 and December 24 were duly received. In relation to the question as to root blight, will say that it appeared during the latter part of July and early in August, when the weather was very hot and dry. The leaves would wilt and in a few days entirely dry up. Sometimes the root would rot, followed by the leaves falling off. In other cases the root would dry up and get woody, with the dark circles running all through it. New leaves, curled inward, would put out from the crown but eventually die off. Very little of this sickness appeared in the late plantings. In all cases except where there was a good close stand it spread very fast. It destroyed about 20 per cent of our crop.

So many different opinions have been given by European professors and directors of agricultural experiment stations in this country that no specific decision as to cause has been arrived at. Beets grown from seed that had been treated with bluestone solution were affected the same as those from seed not so treated. I am of the opinion that climatic conditions, soil, and cultivation have a good deal to do with keeping it down. I would say that in this State where we had irrigated fields with

a regular supply of water, or where subirrigation was obtainable, there were very few roots affected thereby. In Anton Stifft's book, "Die Krankheiten der Zuckerrübe," Professor Sorauer is emphatic in stating that the best preventive in his opinion is thorough irrigation, and this we proved to be the case in Nebraska last year.

Very truly, HENRY S. FERRAR, *Manager.*

BLIGHT OF BEETS IN NEW YORK.

BINGHAMTON BEET SUGAR COMPANY,
Binghamton, N. Y., September 27, 1900.

DEAR SIR: Your letter to the Binghamton Beet Sugar Company was laid before me. I take pleasure in sending what information I can regarding the disease you write of. The following is an extract translated from Dr. R. Buerstenbinder's Zuckerrübe (sugar beet). He is a well-known German authority on the sugar beet. On page 235–236, edition of 1896, he says:

The beet rot is caused by a fungus called *Rhizoctonia violacea.* The diseased beets have a withered appearance, though at times the leaves are healthy while the roots are affected, also vice versa. When the leaves are affected, they die off and become a brownish-black color. When the root is affected, you will notice on the ends of the smaller roots smooth brown or violet spots, which gradually spread over the whole beet. As the spots spread the beet rots. The spots are called forth by the uniting of long twisted violet-colored fungous threads and the outside skin of the beet, some of the threads forcing themselves into the beet and causing the same to rot. This disease is especially found where the soil is damp and undrained or when stable manure has been used for spring fertilizing.

Very recently a peculiar disease has threatened the crop, which is called by Professor Kühn "cell rot." This disease seems to be like the potato sickness. The meat of the beet becomes spotted, black, and rotten. Fungous mycelium causes this, and destroys the cells of the beet.

In the last few years a kind of beet rot appeared in Germany called the dry rot. It was noticed that on the application of lime to the fields the fungus also appeared, but on the use of the lime cake it seemed to stay away. By using the lime cake a greater amount of lime was brought on the fields.

Very respectfully,

A. W. HOPPENSTEDT,
Head Chemist of the Binghamton Beet Sugar Company.

OCTOBER 3, 1900.

Your letter inquiring about a root blight on sugar beets received. This has not been at all serious with us as yet. My attention has been called to a few pieces where in spots there has been a rot or blight, but it has not been serious enough to affect the crop much. Two years ago, when we had a very dry July and a very wet August, we had some instances of rot, but these were not serious enough to do any great harm. The past season has been exceedingly dry, and I have heard of no instances of rot in any of the fields. We are just commencing to harvest, and from present indications the yield will be very satisfactory, considering the season.

We are in close touch with Cornell University, and they will do everything in their power to ferret out any trouble of this kind. I have visited several fields with their representative, and in some instances the Bordeaux mixture has been applied to see what effect it would have where the rot has made its appearance. I hope we may be spared any pest of this kind for some years to come. If we find any of it in our harvest would be glad to report to you any information we may be able to gather concerning it.

Very truly, yours, BINGHAMTON BEET SUGAR COMPANY.
J. E. ROGERS, *President.*

No Blight in Washington.

Washington State Sugar Company,
Waverly, Wash., January 5, 1901.

I have not yet completed the organization of this company, and can not give you as full information as you ask for. I do not know anything about the diseases that have affected the beet root in different parts of the country. We have had nothing like root blight, root rot, or anything of that sort. Last summer was exceedingly dry, and we noticed on the small roots on a few of the beets something like white mold, but it did not affect them to any considerable extent, and I think it was owing to the extreme drought.

If anything of the sort appears in the future, I shall be glad to give you all the information I can respecting same.

Yours, truly, D. C. Corbin.

Serious Damage in New Mexico.

The Pecos Valley Beet Sugar Company,
Carlsbad, N. Mex., October 8, 1900.

Replying to yours of the 24th, I send you herewith copy of a letter I recently wrote to Mr. R. M. Allen, of Nebraska, touching upon the subject mentioned in your letter. I also beg to advise that this year we planted a few acres in beets for experimental purposes, and part of it is affected with root rot, and also with leaf blight. I have sent a number of samples of our diseased beets to Newton B. Pierce, pathologist, Santa Ana, Cal., and have asked him to send me his report on the same.

I am not sure just what causes this root rot or blight in our country, because we find it on nearly every kind of soil we have here, and even where alfalfa has been plowed under, nor do I see any way to avoid it. We have treated the root rot by excessive irrigation, by very slight irrigation, by deep and shallow cultivation, but the rot seems to be about the same on all lands, no matter how treated. I can say this, however, that beets planted late, say in June, are not affected to any considerable extent, and not nearly so much as those planted early in the spring—in March, April, and early May.

Yours, very truly, A. S. Goetz, *General Manager.*

January 17, 1901.

As you are no doubt aware, we raised only about 12 acres of beets the past season, and these were grown for experimental purposes. Even on the 12 acres we had the same trouble that we had the previous years. We term the disease the black root rot, and not the "root blight," as so many seem inclined to call it. Our beets are put into the ground, germinate perfectly, and grow well until they are about two or three months old, then the black root rot affects them, commencing on the tips of the roots and gradually working around the beet until almost the entire beet is affected. The leaf growth dies down and almost wilts completely. In many cases the top portion of the beet lives and throws out new leaf growth in the fall of the year, and, while this top portion has a satisfactory percentage of sugar and a good purity, the rot so diminishes the tonnage that in many damaged fields it will not pay to harvest them. We have tried all methods of cultivation and irrigation without any effect, and are at a loss to state the absolute reason for this disease. It may be that our soil is lacking in nitrogen and is very strong in mineral substance. However, on all alfalfa lands and on lands that have been heavily manured by sheep, both of which put considerable nitrogen in the soil, we have had the same conditions. . . . We did not run this past season, so can not fill out your blank.

Yours, very truly,

Pecos Valley Beet Sugar Company.
Per Christian.

REPORT FROM AN OHIO FACTORY.

THE CONTINENTAL SUGAR COMPANY,
Fremont, Ohio, October 2, 1900.

Your inquiry regarding root blight at this point has been received, and at the same time I received a request on the same subject from the director of the experiment station at Wooster, Ohio. I inclose you herewith my observations on the trouble which we had here this season with leaf blight, but as far as the root trouble you speak of is concerned, we have had none of it here this season which has come under my observation. Occasionally we have found rotted beets, but no more so than is customary under ordinary circumstances, and there has been no distinctive or widespread disease of the character you mention.

My opinion is that every farmer should thoroughly and carefully spray his beets from two to four times in the season, and I think that by doing this he would save himself much trouble and loss from insects and diseases. My idea would be to spray the crop as soon as the leaves begin to appear with Bordeaux mixture and some arsenical poison. The strength, of course, would have to be regulated to the requirements of the young and tender plant. This preliminary spraying would, I think, be of assistance at that time, and I would then suggest spraying again soon after the beets were thinned and also twice during the month of July.

This matter of spraying need not excite the farmer nor cause him apprehension as to the matter of expense, as it can be very easily, rapidly, and cheaply done, and it is my belief that it would materially decrease injury from disease and insects.

Referring to the request for observations at this point touching sugar beets grown here and afflicted with what has been called the root blight, the writer would state that during the early part of the season, when the roots were still threadlike, there was prevalent in some fields a blackening of the outer covering of the root. The main artery of the beet retained a white silverlike appearance after the black outer part had been scraped off, and it was not long before the root shed this black outer skin and went vigorously ahead with its normal growth. I have noted this same condition in Colorado and Utah, and do not consider it at all serious, for, as far as my observations have extended, the beets always do well after the shedding of the outer skin.

As the season advanced here we noted about the latter part of July that in some cases an inch or two of the end of the taproot became very dark, tough, and woody. We found this condition to exist in a good many beets which we pulled out at that time, but since then we have seen nothing further of it, and out of over 1,000 samples which we have taken during the last thirty days we have not found one-half of 1 per cent affected in this way. As far as the so-called root blight which destroys the entire beet is concerned, we can say without hesitation that we have not been affected with it in this locality this season; but there appeared about the latter part of July and the early part of August, immediately following heavy rains succeeded by extremely hot moist days, a leaf disease which, for want of a better name, we have called leaf blight.

This disease first appeared as brown spots on the large and older leaves. Gradually after these spots had appeared other spots seemed to come on the outer edges of the same leaves, and the edges began to curl and turn brown, until finally the whole leaf in many cases became brown and dried, having the appearance of dried tobacco, and, on picking one of these leaves and rubbing it in the hand, it would crumble and break down into a dust very rapidly.

This trouble appeared in nearly every field to a greater or less extent. Where it was the worst, the outer leaves of the plant, which had been large and vigorous, disappeared entirely. In one case especially, where, from the luxuriant growth of the foliage, it had been almost impossible by a casual glance to distinguish the rows,

the appearance of the field changed within a period of two weeks so that no more foliage was apparent than could have been seen in the latter part of June. The disease did not appear to attack the younger leaves in the center. These seemed to continue their growth, new ones being put out from the center of the plant again, and by the latter part of September this same field had nearly recovered the appearance which it had before being attacked by the disease.

The disease appeared to run its course in from four to six weeks, beginning about the 20th to 25th of July and ending the latter part of August and first of September.

In a few exceptional cases the disease entirely destroyed the leaves, and, where this occured, rotting and decay of the beet set in, and total destruction of the root ensued, but the disease progressed from the crown downward and not from the taproot upward. Careful examination and experiments went to show that this disease of the leaves at the time caused a decided lowering in the sugar content and a large decrease in the purity, but since the 1st of September the increase in both sugar and purity has been very satisfactory; and to-day fields that were badly affected by this leaf blight seem to average as well in sugar and purity as those in which the disease only appeared to a very slight extent. An especially notable thing in regard to this leaf blight was that it attacked the older and coarser leaves, and left the young and tender leaves in the center of the beet practically untouched. Nor did it appear to attack, to any appreciable extent, very late-planted beets.

After the disease was discovered and it was noted that it was doing considerable harm, it was too late, and for other reasons it was impracticable, to make any thorough experiments with regard to a remedy. The Ohio State entomologist visited us, examined the fields carefully, and gave as his opinion at the time that it was a fungous growth which had made good progress under favorable weather conditions of much moisture followed by hot and sultry weather.

The writer has, within the last few days, seen in a German publication a colored plate showing this exact condition of the leaf, but has not had time as yet to translate the text and learn what they have to say regarding it.

Respectfully,

CONTINENTAL SUGAR CO.,
Per C. E. MITCHELL.

REPORT FROM AMERICAN BEET-SUGAR COMPANY.

OFFICE OF AMERICAN BEET-SUGAR COMPANY,
New York, N. Y., March 10, 1901.

At Grand Island, Nebr., the disease appeared the latter part of July and early in August. The tonnage of beets was reduced from 1 to 2 tons per acre.

The leaves would wilt and in a few days entirely dry up. Sometimes the root would rot, followed by the leaves falling off. Other times the root would dry up and get woody, with the dark circles running all through it. New leaves, curled inward, would put out from the crown, but eventually nearly all would die off. Very little of the sickness appeared in the late planting. In all cases, except where there was a good close stand, it spread very fast.

So many different opinions have been given by European professors and directors of agricultural stations in this country, that so far no specific decision as to the cause has been arrived at, so far as I know. Beets grown from seed that had been treated with bluestone solution were affected the same as seed not so treated. I am of the opinion that climatic conditions, soil, a good stand, and cultivation have a good deal to do with keeping it down. I would say that in this State, where we had irrigated fields with a regular supply of water, or where subirrigation was obtainable, there were very few affected roots. In Anton Stift's book, "Die Krankheiten der Zuckerrübe," Professor Sarauer is emphatic in stating that the best preventive, in his opinion, is through irrigation, and from personal experience I have proven this to be the case in Nebraska last season.

At Norfolk, Nebr., the disease appeared the latter part of July. The season had been dry, and when it did finally rain it was immediately followed by very hot weather. The previous winter had been dry, so the ground was not in good condition in the spring. It was first noticed by the leaves being affected. However, when beets were pulled the dark rings could also be seen in the root. Some of the beets were affected to such an extent that they rotted in the ground. All fields were affected more or less, and all beets in the field lost their leaves, part of them recovering to a certain extent.

A few fields were damaged to the extent of 50 to 60 per cent. In general our tonnage was reduced from 1 to 2 tons per acre.

In my opinion the trouble was caused by unfavorable soil and climatic conditions.

At our factory at Chino, Cal., the season of 1899 was very dry. The disease appeared about six weeks or two months after planting, and progressed rather fast on those affected. The beet stopped growing and sent forth many side roots or fibers; inside of the root was woody, and the cells turned black. On account of great drought it is impossible to tell what proportion of the loss was due to blight and what to climatic conditions.

At Oxnard, Cal., the disease appeared at an early age of the plant—shortly after thinning. The climate was generally dry. The beets were grown principally on land that had become strongly alkaline by evaporation, owing to lack of rain during the last three years. The leaves curled up, turned yellow, a gummy substance running from the stems owing to the breaking down or disintegration of the cell fiber. The root stopped growing, making only thick, heavy side roots. Upon cutting the root, the meat immediately turned black.

As the blight appeared only on strongly alkaline lands, the damage was hardly appreciable if the whole crop be considered.

The cause appeared to be unfavorable climatic and soil conditions. Where the soil was favorable and sufficient moisture available, no blight appeared.

At our factory at Rockyford, Colo., a so-called blight appeared sporadically, but it is doubtful if it was really blight. The damage suffered was very slight.

Respectfully yours,

JAMES G. HAMILTON,
Secretary American Beet Sugar Company.

REPORTS OF DIRECTORS OF STATE EXPERIMENT STATIONS.

In my annual reports I have always included the results of the experiments with sugar beets in the various States as reported by the directors of the experiment stations. This work is largely under the supervision of the directors, and I have felt that a report on the progress of the sugar industry would be incomplete without the results and observations of the experiment stations.

Up to the time of submitting this report several of the States that have been most active in prosecuting the investigation have failed to make response to my letter asking for these data. Those States not included in the list of reports are not represented for this reason. Letters have been received from some of them stating that data of results are being compiled and will be furnished as soon as completed, but inasmuch as this report must be published before the close of the fiscal year, June 30, 1901, reports from such States will have to be omitted unless received some time before that date.

The following are replies to letters of inquiry sent out by myself calling for this information:

ARIZONA.

Report of R. H. FORBES, M. S., Director and Chemist of Experiment Station, Tucson, Ariz., January 11, 1901.

Replying to yours of January 7, I am sending you our eleventh annual report, just issued, which contains a digest of our results with sugar beets for last year. These results are stated in two different places, pages 164 and 185.

In interpreting these results I will call your attention to Professor McClatchie's usage in relation to "available sugar per acre." He does not state total sugar per acre contained in the beets, but deducts from total sugar per acre, as found by multiplying tonnage into percentage of sugar in beets, the weight of soluble solids not sugar contained therein. On page 185, in order to introduce a means of comparison between my results and his, I have calculated "available sugar per acre" by his plan in the last column. According to your desire, therefore, you can use one statement or the other, based upon the data of the report.

Sugar beets were planted to a limited extent in Arizona last year, chiefly by the station, but also by a few farmers on the Upper Gila, who found them valuable as stock food. The season was exceedingly dry and the beets suffered in consequence.

There is no factory agitation here and no prospect of any factories being constructed.

The following statement prepared by Professor Forbes is taken from the report referred to above:

Climatic conditions having seemed favorable to beet culture on the Upper Gila, the station undertook to extend its work in this line to this district. In order that the experiment might be as conclusive as possible, Mr. C. G. Arney, trained to this work on the experimental farm, was put in charge of the plots. The ground and part of the labor was furnished by various public-spirited citizens of Safford, Thatcher, and Pima. Various types of soil were chosen, and plantings were made from February 23 until late summer. The seven main plots were of sufficient size to afford acreage tests from time to time, some of the results being stated below. The work suffered in several instances from the unusual scarcity of irrigating water this year, and the yields may be considered less than the average probability for this region.

Of these plots Nos. 3 and 8 were the only ones which did not suffer seriously for lack of water, and the total sugar per acre contained (2,267 and 3,361 pounds, respectively) is a fair result, taken in connection with the percentages of sugar (15.9 and 13.7) and the purities (84.5 and 83). Owing to the adversity of the season, it is thought that better results may be secured by a continuance of the work for the ensuing year.

Results on Upper Gila beet plots, planted February 28 to March 19, 1900.

Number, name, and location of plot.	Kind of soil.	Results, July 2–6, 1900.				Results, Aug. 3–13, 1900.				
		Sugar in beets.	Coefficient of purity.	Beets per acre.	Sugar per acre.[1]	Sugar in beets.	Coefficient of purity.	Beets per acre.	Sugar per acre.[1]	Available sugar per acre.[2]
		P. ct.		*Tons.*	*Lbs.*	*P. ct.*		*Tons.*	*Lbs.*	*Lbs.*
1. Morris, Layton	Sandy loam	9.9	75.2	5.9	1,174	10.4	72.4	7.3	1,521	940
2. Brinkerhoff, Thatcher.	Adobe	12.0	82.5	4.86	1,169	13.6	81.6	7.38	2,006	1,554
3. Hubbard, Pima	Heavy adobe	12.2	81.8	4.43	1,077	15.9	84.5	7.13	2,267	1,852
4. Hoopes, Thatcher	Sandy	13.8	79.5	3.34	924					
5. Zundle, Thatcher	do	14.8	84.6	2.9	859	13.0	85.4	5.74	1,491	1,237
7. Mrs. Layton, Thatcher.	do	10.55	80.2	4.7	989	12.3	79.5			
8. Marshall, Pima	Silty loam	11.0	78.1	8.6	1,892	13.7	83.0	12.3	3,361	2,679

[1] The "sugar per acre" in the above table is total sugar per acre contained in the beets.
[2] "Available sugar per acre" is approximately that which can be recovered in the process of manufacture.

Report by A. J. McCLATCHIE, Agriculturist of the Station, from annual report of the station for 1900.

Experiments were conducted with sugar beets this year, mainly for the purpose of testing methods of irrigation, other points in their culture having been pretty well settled by previous experiments. A sowing was made September 12 in a gravelly loam, and irrigated at once, as is necessary at this time of year. The winter being quite mild a fair growth was made. Samples taken April 2 gave the following results: Average weight of beets dug, 12 ounces; yield per acre, 11.5 tons; sugar in beets, 14.7 per cent; purity coefficient, 83.3. These are probably as good results as could ordinarily be expected from seed sown on the earliest practicable autumn date.

At the close of the year 1899 bulletin 31 was issued giving the result of the year's work. The averages from ten plats sown during January and February, 1899, were as follows: Yield per acre, 9.75 tons; per cent sugar in beets, 15; purity coefficient, 77.7; available sugar per acre, 2,010 pounds. The most important of the conclusions from the work of the year was that winter-sown beets are not benefited, and may be injured, by early irrigation, provided the soil has been thoroughly irrigated previous to seeding. The indications were that the most advantageous time to begin irrigating is when the beets are two to three months old.

A plat sown December 26 and first irrigated April 1 gave the following results:

	Sugar in beets.	Purity coefficient.
June 15	15.0	88.1
July 1	16.4	88.4
July 11	16.4	86.0
July 30	16.9	84.4

The yield upon the latter date was 14.5 tons per acre, giving an approximate yield of available sugar per acre of 4,050 pounds, the highest yield yet obtained from any of the experimental plats during the past four years. This yield of sugar per acre evidently remained about constant during all of June and July, the increase in the percentage of sugar being just about counterbalanced by a decrease in the purity coefficient. Only a tenth of an inch of rain fell upon the plat from the time of seeding until the first irrigation, over three months later, during which period they made an excellent growth. This result was accomplished by a thorough irrigation of the soil previous to seeding.

COLORADO.

Report by L. G. CARPENTER, Director of State Experiment Station, Fort Collins, Colo., January 11, 1901.

In answer to your inquiry of January 7, regarding sugar beets in Colorado during the past year, a general statement regarding the conditions of the State during the past season and the progress of the sugar-beet industry will probably answer your needs.

Three beet-sugar factories have been in operation during the past season: One at Grand Junction, which began operations the year before; one at Rockyford, and one at Sugar City—the last two being in the Arkansas Valley. The last two have had a most excellent run this season. The yield of beets has been good and the sugar content high. The exact acreage I am unable to give, but it has been in the neighborhood of 9,000 acres for these last two factories. The month of April in the Arkansas Valley was abnormally wet, there being a rainfall of over 7 inches as compared with the previous average of 0.89 inches. During May and June the rainfall was very nearly the normal, and during the subsequent months it was below the average. This gave good conditions for ripening and favored a large content of sugar. The average sugar content at Rockyford was nearly 17 per cent, some beets running as high as 26 per cent of sugar. The price was based on a sliding scale, so that these beets brought $7.67 per ton.

As the sugar industry seems to have been put on a commercial basis the station has done less during the past year than previously in experimental work, and has

grown very few on the station grounds this year, though it has grown some by cooperation in the State.

The town of Loveland is likely to have a factory put up this season. Contracts for beets have been made and the company is prepared to erect the factory. Denver is agitating the construction of one, and two or three more are planned in the Arkansas Valley. Our bulletins 42 and 51 give facts regarding tonnage and sugar content for two years' trials in the State

CALIFORNIA.

Report by E. W. HILGARD, Director of State Experiment Station, Berkeley, Cal., January 10, 1901.

In reply to yours of January 7, regarding the conditions of sugar-beet culture in this State, and our experiments, I would state:

The crop conditions in this State during the past year have been very unfavorable to the sugar beet, on account of the exhaustion of the moisture in the lower layers of the soil mass; and in consequence of this the quantity was small, although the quality was high. The extent to which the beet was planted during the past year was less than usual, because of the discouraging results of the preceding years. The lands naturally moist have been generally planted, while the higher lands have been left out.

The only places in which the establishment of sugar factories have been mentioned in the past year have been Sacramento and Stockton, but no definite action has been taken. Quite lately the subject has been broached in the Perris Valley, in Riverside County. No factories will be built during the coming year. The factories already in existence are somewhat anxious in regard to obtaining a proper supply of beets to keep them running. They are inclined to put in beets on their own land and on their own account, in order not to be subjected to the results of the discouragement which the neighboring farmers are laboring under.

Our object in our work with sugar beets during the season of 1900 was to test some special seeds sent us from Europe, but the results were wholly abnormal and are not worth mentioning. We will probably make similar experiments at our substation during the coming season, but do not think it necessary to test the production of beets in various localities of the State any further, as the ground has been well covered by experiments made under the initiative of the factories.

Our experiments indicate an average production of from 10 to 12 tons per acre in good land; as much as 18 tons has repeatedly been grown. The sugar content when the beets have been properly handled has always been high, as is indicated by the fact that the factories have placed their normal figure at 15 per cent. In California the purity is, as a rule, higher than elsewhere, ranging between 85 and 91. As to the cost of production and net profit the several factories can give the best information.

The last three years have been so abnormal in reference to agricultural production in California at large that the discouragement in regard to beet-sugar production is not likely to exert any permanent influence upon its pursuit in this State. In the past no such succession of dry seasons has occurred as far as records reach, and the natural presumption is that it will not again occur soon enough to influence the present generation in the pursuit of the beet-sugar industry.

IDAHO.

Report by S. AVERY, Chemist of State Experiment Station, Moscow, Idaho, January 14, 1901.

In accordance with your request of the 12th instant, I take pleasure in handing you herewith a report of the work in sugar-beet culture for the past year.

The crop conditions were unfavorable in those parts of Idaho which depend on rainfall. July and August were hot and dry.

The Department distributed about 300 pounds of seed, without any restriction as to ocality. Two franks for mailing samples were sent to each grower in the fall, but :omparatively few samples were received for analysis.

So far as I know, Payette, in Canyon County, is the only point agitating the establishing of a factory.

The experimental work of the station during 1900 was to determine if a profitable yield (with a satisfactory sugar content and purity) could be obtained, so that we could advise farmers to grow beets for the factory at Waverly, Wash. The field work was under the charge of the agriculturist, Professor French. The crop was almost a failure.

The experiments on the campus were under the direction of the horticulturist, Professor Huntley. Certain plats were on ground that had received a heavy coating of manure three years ago; part were in a soil almost devoid of humus. In the latter case the results were similar to those of the field experiment. The plats which had previously been manured gave a very satisfactory yield. The complete data has not been compiled, but will be given later in a station bulletin.

My experience in beet culture in Idaho is confined to the past season, but from a careful study of the records of this station, from comparing conditions with those of other sections, and from a comparison of notes with the horticulturist and agriculturist, I offer the following opinions on the possibilities of beet culture in Idaho: (1) Beets of high sugar content and purity can be raised in all the agricultural sections; (2) in the parts of the State depending on rainfall, there will be difficulty in securing a satisfactory yield except in abnormally wet seasons, especially during July; (3) the higher irrigated portions of the State may have to contend with an occasional abnormally cold season; (4) I see no reason why the lower irrigated parts, such as Washington, Canyon, and Ada counties, should not be most admirably adapted to the culture of the sugar beet, and I trust that the extensive experiment planned for Payette and vicinity may be successful in all respects.

A number of farmers raised beets in Idaho under contract with the Waverly sugar factory. Mr. Paul Leuschel, Moscow, Idaho, had charge of the contracts. He can doubtless furnish exact figures. Those farmers that I have talked with report that they received pay for beets of about 16 per cent sugar and for 3 to 4 tons per acre.

The results of experiments during the season, except yield per acre, are given in the following table:

Results of sugar-beet experiments in Idaho, 1900.

No. of experiment.	Variety.	Weight of beets.	Sugar in beet.	Sugar in juice.	Purity coefficient.	Name of grower.	Location.	Remarks.
		Oz.	*P. ct.*	*P. ct.*				
100	Klein[a]	14.6	15.5	16.3	84.0	W. A. Zumhof	Moscow	Average.
101	.....	29.0	15.6	16.4	82.8	H. R. Russell	do	
102	Klein	18.9	16.9	17.8	83.2	J. M. Thompson	Rich	
103	.....	16.3	16.8	17.7	83.5	J. G. Jarron	Moscow	
104	.....	18.0	15.8	16.7	84.4	George Davis	Wilford	
105a	Vilm.[b]	13.3	17.3	18.2	89.6	W. A. Zumhof	Moscow	
105b	do	16.3	16.3	17.2	87.7	do	do	Grown on high ground.
105c	Klein	26.2	15.9	16.8	85.2	do	do	Largest in crop.
106	do	20.4	15.9	16.8	87.9	H. T. Coats	.....	
107	do	10.9	18.7	19.7	86.7	D. J. Waite	Teakean	
108	do	25.7	15.6	16.4	85.8	R. D. James	Russell	
109a	.....	25.0	15.2	16.0	83.3	N. M. Hawley	Moscow	One red beet in sample.
109b	.....	25.2	13.3	14.0	79.5	do	do	
110	.....	26.5	17.9	17.9	86.9	D. Jarrett	do	
111	.....	5.7	16.3	17.2	88.6	P. C. Olesen	do	
112	.....	11.6	18.1	19.1	88.4	O. O. Hurt	do	Average.
113	.....	60.4	14.1	14.9	80.9	do	do	Very large.
114	.....	20.5	16.9	17.8	89.0	J. H. Tyler	do	

[a] Kleinwanzlebener. [b] Vilmorin.

Results of sugar-beet experiments in Idaho, 1900—Continued.

No. of experiment.	Variety.	Weight of beets.	Sugar in beet.	Sugar in juice.	Purity coefficient.	Name of grower.	Location.	Remarks.
		Oz.	*P. ct.*	*P. ct.*				
115	Klein...	63.5	13.7	14.5	81.9	Station	Moscow	Large beet; fertilized plat.
116	....do...	16.2	18.1	19.1	91.3	.....do	.....do	Perfect beets; fertilized plat.
117	....do...	15.9	15.8	16.7	85.2	.....do	.....do	
118	....do...	5.7	16.8	17.7	87.6	.....do	.....do	
119	....do...	10.2	14.3	15.1	83.4	Miss A. Bowman	.....do	
120	Vilm ...	19.7	14.1	14.9	75.9	Station	Plat 38	Medium-sized.
121	....do...	20.3	14.2	15.0	82.4	.....do	.....do	Do.
122	....do...	5.5	15.3	16.1	84.7	.....do	.....do	Very small.
123	....do...	45.4	12.3	13.0	75.1	.....do	.....do	Largest in sample.
124	Klein...	19.6	13.6	14.3	80.7	.....do	Plat 37	Medium-sized.
125	....do...	12.9	16.6	17.5	86.2	.....do	.....do	Do.
126	....do...	73.2	13.9	14.7	80.8	.....do	.....do	Largest in sample.
127	....do...	8.8	17.4	18.3	91.0	.....do	.....do	Small.
128	....do...	31.1	14.3	15.1	83.9	.....do	.....do	
129	Vilm ...	32.3	15.5	16.3	86.7	.....do	Plat 6	Large.
130	....do...	4.5	15.7	16.6	87.4	.....do	.....do	Small.
131	....do...	16.4	16.1	17.0	88.5	.....do	.....do	Medium-sized.
132	Klein...	14.7	15.5	16.4	85.4	.....do	Plat 1	Largest in sample.
133	....do...	14.4	16.8	17.7	92.1	.....do	.....do	Medium-sized.
134	....do...	3.6	17.2	18.1	88.7	.....do	.....do	Small.
135	Vilm ...	34.8	13.9	14.7	82.6	.....do	Plat 38	Large.
136	....do...	11.7	14.9	15.7	84.8	.....do	.....do	
137	....do...	40.9	15.2	16.1	82.9	.....do	.....do	
138	Klein...	33.5	16.1	17.1	89.0	.....do	Plat 37	
139	....do...	25.4	16.5	17.4	87.8	.....do	.....do	
140	.....	19.9	14.7	15.5	81.5	C. J. Edwin	Moscow	
141	.....	7.6	21.3	22.5	85.2	J. M. Garrison	Nezperce	Somewhat desiccated.

MARYLAND.

Report by H. J. Patterson, Director State Experiment Station, College Park, Md., January 14, 1901.

In answer to your circular letter of 2d instant, would say that all the information which we have in reference to sugar beets and results with experiments as far as compiled are given in Bulletin No. 61 of this station, a copy of which we send you by this mail.

There is but little interest at this time among our farmers as to sugar beets; in fact, it has been pretty well shown that there are no large areas in our State adapted to the growing of sugar beets, especially not enough to make it desirable to put up a factory.

MINNESOTA.

Report by W. M. Hays, Agriculturist of State Experiment Station, St. Anthony Park, Minn., January 29, 1901.

Your letter of January 4 to the director of this station is in my hand for answer, as our director has gone to California to spend the winter.

The crop conditions of the season of 1900 were very peculiar. It was exceedingly dry during May and June, and wet during the remainder of the year. I believe the factory at St. Louis Park had about the same acreage to draw upon as last year, 2,000 acres.

I do not know of any active organization trying to establish a factory in Minnesota at present. As you know, New Ulm, Albert Lea, Winona, and other points have "had their latchstring out." I presume no new factory will be built in 1901.

In variety tests at the station the results were as follows: Tonnage per acre, 15 tons; cost of production, $33 per acre; sugar content, 14 per cent; coefficient of purity, 83.

MISSOURI.

Report by H. J. WATERS, Director of State Experiment Station, Columbia, Mo., January 11, 1901.

Replying to your circular of the 2d, will say that the results of all of the tests made by the experiment station and the United States Department of Agriculture, extending over a number of seasons and embracing all sections of the State, indicate that Missouri is not well adapted to the production of sugar beets containing a high content of sugar and with a high degree of purity. Consequently the experiment station has made no experiments along this line during the past two years, and has no new data on this subject. There is no agitation in this State in regard to the building of factories or the establishment of this industry.

MONTANA.

Report by F. W. TRAPHAGEN, Special Agent in Charge of Beet-sugar Investigations, State Experiment Station, Bozeman, Mont., January 18, 1901.

Director Fortier has handed your letter to me for reply.

The conditions for the production of sugar beets, as judged by the product, were not favorable last season. Because the seed was received too late, there was little planting done in the State last year.

A sample from Sunnyside Stock Farm, Cascade County, grown on alkali land, showed the following results on analysis: Average weight, 5 ounces; Brix degrees, 22.5; sugar in juice, 15.5 per cent; sugar in beet, 14.72 per cent; purity coefficient, 70.

Analysis of beets grown at the experiment station yielded the following results: Average weight, 6½ ounces; Brix degrees, 18; sugar in juice, 14.2 per cent; sugar in beet, 13.5 per cent; purity coefficient, 79; yield per acre, 8¼ tons.

Billings, Bozeman, and Miles City are agitating in a somewhat passive way the establishment of factories. No factory is in sight in the near future. The beets at the station were from the rotation plats and were used in experimental pig feeding with other food with highly satisfactory results.

The results of this past season, taken as a whole, are among the poorest of the several years of our experiment.

Speaking of the results of experiments covering several years past, I feel safe in saying that the tonnage can be conservatively placed at 15 to 20 tons per acre, and the cost of production at about $20 per acre. A sugar content of 14 per cent and 80 purity can be maintained. Additional information concerning previous results is to be found in our annual reports.

NEW MEXICO.

Report by ARTHUR GOSS, Vice-Director of Experiment Stations, Mesilla Park, N. Mex., January 29, 1901.

Your favor of January 5, to the director of this station, has been referred to me. In reply to your questions I will say that crop conditions in New Mexico last season were unusually dry. The only beets grown in the Territory during the season of 1900, so far as I know, were in connection with the sugar factory at Carlsbad, and with the experimental work at the station here.

Factories have been mentioned in connection with a number of places in the Territory, notably Santa Fe, the Animas Valley, and Roswell, but I am unable to say what places will build factories in 1901–2.

The purpose of the experiments with sugar beets at the New Mexico station and substations during 1900 was to continue the tests of varieties in different parts of the Territory, as has been done for several years past. The work at the central and substations, as well as the cooperative work by farmers in different parts of the Territory, has demonstrated that remarkably high-grade beets can be grown in the Territory, especially in the northern portion. This fact will become more apparent by referring to the following table in which are given the average results, so far as secured, from Santa Fe and San Juan counties since 1897:

Results of analyses of beets grown since 1897 in Santa Fe and San Juan counties, N. Mex.

Year.	Santa Fe County.				San Juan County.			
	Number of samples.	Weight of beets.	Sugar in beet.	Purity coefficient.	Number of samples.	Weight of beets.	Sugar in beet.	Purity coefficient.
		Pounds.	*Per cent.*			*Pounds.*	*Per cent.*	
1897	24	1.66	14.33	79.6	14	2.00	15.64	81.3
1898	10	1.10	17.76	82.1	10	1.20	16.77	86.4
1899	4	.70	18.15	82.5	8	1.47	17.25	82.2
1900					6	1.32	19.43	87.7

In the following table are given in detail the results secured last season at the central station at Mesilla Park, Donna Ana County, and at the substations at Las Vegas, San Miguel County, and at Aztec, San Juan County. These beets were grown, sampled, and shipped strictly in accordance with instructions and, consequently, represent what can be secured under favorable conditions. Special care was taken to guard against evaporation during shipment, and to analyze as soon as possible after digging. The beets were all received in practically perfect condition, very little loss of moisture having occurred:

Results of analyses of sugar beets grown at the New Mexico Experiment Station, and the Las Vegas and Aztec substations, 1900.

CENTRAL STATION, MESILLA PARK.

Variety and source of seed.	Seed furnished by—	Planted.	Harvested.	Average weight.	Sugar in juice.	Sugar in beet.	Purity coefficient.
				Pounds.	*Per ct.*	*Per ct.*	
Vilmorin, France	U. S. D. A., No. 3941	Apr. 7	Nov. 14	1.16	10.0	9.5	82.9
Strandes, Germany	U. S. D. A., No. 3942	do	do	1.07	12.5	11.9	87.2
Dippe, Germany	U. S. D. A., No. 3944	do	do	1.01	14.2	13.5	88.8
Mrozinski No. 1, Russia	U. S. D. A., No. 3943	do	do	.94	11.3	10.7	70.0
Mrozinski No. 2, Russia	U. S. D. A., No. 4416	do	do	1.14	14.3	13.6	74.1
Licht Improved	F. O. Boyd, New York	do	do	1.25	12.4	11.8	72.1
Average		do	do	1.10	12.45	11.83	69.1

LAS VEGAS SUBSTATION.

Strandes, Germany	U. S. D. A., No. 3942	May 5	Dec. 1	1.31	14.2	13.5	82.6
Dippe, Germany	U. S. D. A., No. 3944	do	do	1.08	15.8	15.0	87.9
Mrozinski No. 1, Russia	U. S. D. A., No. 3943	do	do	1.18	15.9	15.1	84.6
Mrozinski No. 2, Russia	U. S. D. A., No. 4416	do	do	.80	20.0	19.0	90.0
Licht Improved	F. O. Boyd, New York	do	do	1.30	16.3	15.5	83.6
Average		do	do	1.13	16.44	15.62	84.5

AZTEC SUBSTATION.

Vilmorin, France	U. S. D. A., No. 3941	May 1	Nov. 3	1.34	20.7	19.7	90.0
Strandes, Germany	U. S. D. A., No. 3942	do	do	1.19	21.4	20.3	88.8
Dippe, Germany	U. S. D. A., No. 3944	do	do	1.63	20.1	19.1	88.7
Mrozinski No. 1, Russia	U. S. D. A., No. 3943	do	do	1.25	21.1	20.0	90.6
Mrozinski No. 2, Russia	U. S. D. A., No. 4416	do	do	1.22	19.0	18.1	76.6
Licht Improved	F. O. Boyd, New York	do	do	1.28	20.4	19.4	87.9
Average		do	do	1.32	20.45	19.43	87.1

We believe the showing made by the Aztec substation, Santa Fe, and by other places in the Territory, is worthy of careful consideration by capitalists. In the best beet-producing sections of the Territory can be found plenty of land, water for irrigation, coal, and limestone for the maintenance of sugar factories; and the composition of the beets which can be produced in these sections is certainly very much better than that of the beets grown for most of the sugar factories now in operation.

While we believe that the yield and cost of production under field conditions can not be determined with very great accuracy when working with small experimental plots, still the figures we have secured would seem to show that satisfactory results can be secured in that connection in the best beet-producing sections of the Territory. For example, the superintendent of the Aztec substation reported yields this year, for the different varieties, ranging from 11.3 to 16 tons per acre, and estimated the cost of production per ton at $2.50.

NEW YORK.

Report by W. H. JORDAN, Director of State Experiment Station, Geneva, N. Y., January 7, 1901.

Your inquiries under date of December 31 I can answer only in part.

The crop conditions of the State for 1900 were modified by an unusually severe drought. At the station very small areas were grown. The object of the experiments was to test the influence of heavy manuring in the spring with farm manures as compared with influence of commercial fertilizers upon the sugar content of the beets. For three years we have secured higher sugar content where heavy applications of farm manures have been made than under other conditions.

I do not know of any communities which are agitating the building of new factories.

Report by J. L. STONE, Assistant in Agriculture, State Experiment Station, Ithaca, N. Y., January 12, 1901.

Yours of December 31, making inquiry relative to the status of the sugar-beet industry in the State of New York, is before me. The weather conditions of the early spring were quite favorable, so that farmers got the seed sown in good season and germination was usually prompt and satisfactory. There was little difficulty from storms at this period, and farmers were enabled to get the crop well in hand with but little difficulty on account of weeds.

The middle portion of the season was very dry and the crop suffered in consequence. This was especially true in the southern section of counties where the greatest damage was done. In September abundant rain fell, and although the crop had made little growth to this time, still the plantations were in such conditions that they responded to the supply of moisture in a marked way, and the result was a crop that as to yield surpassed earlier expectations. However, the late growth was not favorable to the development of beets high in sugar content or of high purity.

A much larger area of beets was planted in the State of New York in 1900 than ever before, approximately 7,000 acres being grown. I have not the data at hand to give average results for the crop throughout the State.

As to the investigations conducted by the experiment station, the data of crops grown on the station farm have not yet been computed. We have reports from 22 farmers who conducted cooperative experiments under the supervision of the station. These experiments were for the purpose of determining the relative value of certain varieties of beets, and also the effect of different fertilizers upon the crop. The

results of the experiments with fertilizers have not yet been computed. The table given below shows results obtained with seven varieties, and the averages of all:

Results of variety tests at Ithaca Station, 1900.

Variety.	Yield per acre.	Sugar in beets.	Purity coefficient.
	Tons.	*Per cent.*	
Ziemans	14.85	13.83	82.9
Lichts	15.59	13.69	82.1
Biendorf Elite	14.09	12.49	78.8
J. Simon Le Grande	14.52	12.71	79.1
Vilmorin	11.07	13.91	78.9
Zehringen	13.92	12.04	76.4
Mangold	14.40	12.68	78.9
Average of all reports	12.63	13.04	79.6

Interest in the establishment of beet-sugar factories in this State is large and a number of communities are agitating along this line, but I am not aware of any that have come to a decision to build factories in 1901.

A comparison of the results of experiments conducted by this station during the past four seasons is given in the following table:

Results of analyses of beets grown at Ithaca Station, 1897–1900.

Season.	Yield per acre.	Sugar in beets.	Purity coefficient.
	Tons.	*Per cent.*	
1897	16.95	16.05	83.05
1898	12.38	14.52	83.60
1899	11.48	14.82	80.70
1900	12.63	13.04	78.60
Average of four years	13.51	14.61	81.65

It is probable that the average yield obtained from the experiments referred to above is somewhat above that of the general crop. The probable reason for the falling off in the quality of beets in 1900 is to be found in the climatic conditions mentioned above.

NORTH DAKOTA.

Report by E. F. LADD, Chemist of State Experiment Station, Agricultural College, North Dakota, January 15, 1901.

Replying to your favor of January 4, I inclose a copy of my report on the sugar-beet work of North Dakota for 1900. It is not yet printed, and may not be for several months, being a part of a State document.

Answering your questions in their order, I will say that the crop conditions of the State were the poorest in several years. Wheat that should have yielded at least 60,000,000 bushels gave 12,000,000 to 15,000,000, while the hay crop was almost a total failure. Beet seed planted in May in many instances did not germinate until July, and the heavy fall rains continued the growth and prevented the maturity of the plants. Sugar-beet seed was sent to 225 farmers, well distributed over the State. But forty-nine samples of beets were furnished for analysis.

Sugar beets are not grown at the station, except for stock feed, as our land is not

dapted to growing beets of high sugar content, but gives a large yield. The Red iver Valley is not a sugar-producing region, at least at the present time.

Oakes and Jamestown are working for beet-sugar factories. I am informed that he contract for the factory at Oakes has been let to a company for $587,000, and it s to conduct the factory for the first year. The capacity of the proposed factory is o be 1,000 tons of beets per day, with machinery for working up 500 tons per day.

No experiments were made at the station during the past year. The experiments ontinued in the State since 1891 indicate that under normal conditions where beets are well grown there should be an average of 12 to 14 tons per acre. Some of the most conservative farmers have estimated the cost at about $30 per acre for growing and harvesting the beets. The sugar content has ranged between 13 and 14 per cent for well-grown samples, and the coefficient of purity from 79 to 82. Many samples, poorly grown, not mature, prongy, and otherwise injured, have shown results from 8 per cent upward, while the best samples have given as high as 22 per cent, with a coefficient of purity above 90.

The following is from the copy for my report, to which I referred above:

SUGAR-BEET EXPERIMENTS FOR 1900.

The sugar-beet experiments in North Dakota for 1900 were almost a complete failure when compared with the results for previous years. When we consider the unusual season, and the fact that the wheat and hay crops were the poorest in the history of the State, we do not feel that the results do more than point out that an occasional poor year will occur.

Seeds were sent out to 325 farmers in all parts of the State. The season was so dry in the early summer that only 42 farmers grew any beets whatever. In many instances farmers report that the ground was so dry that seed planted in May failed to germinate until the July rain came. The total snow and rainfall from January to July at Fargo was 6.96 inches. As the ground received but little moisture during the preceding fall, there was not enough soil moisture to insure plant growth, except where the land has been kept well cultivated to conserve the soil moisture. In very few instances was this done with the small plats of ground where beets were to be grown. In early July, beets that had started and withstood the drought began to make very rapid growth, for during the four months, July, August, September, and October, the total rainfall was 18.26 inches, or only about 1½ inches less than the average annual rainfall for Fargo for the previous nine years. The following table shows the rainfall, and the percentage of cloudy weather for the several months:

Rainfall in North Dakota, 1900.

Month.	Precipitation.	Per cent cloudy during the day.
	Inches.	
April	1.82	36
May	.81	32
June	2.11	45
July	3.91	44
August	8.28	64
September	3.27	61
October	2.80	69

The last three months show a condition very unfavorable for sugar formation, and the results are, as might be expected, very low, and not one of the forty-nine samples of beets sent in could be considered as mature. In a few instances the warm weather started a second growth with new top formation and lowered the sugar present as shown by earlier analysis.

As in previous years the beet seed was furnished by the Department of Agriculture, at Washington, and the franking privilege for sending out the seed and for bringing in the beets was granted by the Secretary of Agriculture, thus making it possible for us to continue this line of work in the State.

Five varieties of beet seed were sent out and the tabulated results for the few samples of each variety sent in are as follows:

Results of analyses of sugar beets grown in North Dakota, 1900.

Variety.	Number of beets.	Sucrose.	Coefficient of purity.
		Per cent.	
White Improved Vilmorin	26	9.80	69
Zehringen	6	9.53	64
Leichlets' Kleinwanzlebener	4	14.25	72
Dippe Bros.' Kleinwanzlebener	5	9.22	67
Russian Kleinwanzlebener	8	9.76	68
Total and averages	49	9.81	65

The beets well cared for continued to form sugar quite rapidly. Beets analyzed September 19 gave 8.14 per cent of sugar, and from the same plat those harvested October 18, or one month later, contained 14.46 per cent. Beets from another plat, for the three dates, September 29, October 7 and 28, gave the following percentages of sugar: 9.03, 13.12, and 13.44.

The repeated experiments of this station have demonstrated that North Dakota comes properly in the sugar-beet belt, and already capital has been attracted to the State for developing the industry. It is proposed to continue our sugar-beet experiments for one year more in various parts of the State, after which it is proposed to study specific problems that will prove helpful to the farmers and manufacturers, should the industry become established in the State.

OHIO.

Report by A. D. SELBY, Botanist of the Ohio Experiment Station, March 23, 1901.

As will be perceived from the inclosed compilation of results of analyses of sugar beets in Ohio for 1900, the season was a very unfavorable one, the least favorable, indeed, of any of the four seasons we have conducted the cooperative work. The number of samples analyzed is greater than in 1899.

The root blight, or damping off of seedling beets, Wurzelbrand, of the Germans, was not largely complained of. In growing seedling beets in the pathologium at the station, Wooster, we have had a good deal of it, and find that it is therein due to the sterile fungus, Rhizoctonia. We have also found this fungus upon field-grown beets as well as upon potatoes.

The root rot of large beets has not been complained of to any extent. We have found unmistakable instances in our beet patches at Wooster of the occurrence of heart or dry-rot, Herz- und Trokenfäule of the Germans. This is not at all evidence as to the distribution of the trouble. We do not know to what extent it may have occurred in the beet fields, only that we have had no complaint of it.

Beet scab was more or less prevalent among the beets I observed. I found at Wooster also several examples of the crown gall of the sugar beet, and at least one grower in Sandusky County had quite a little of this trouble.

By far the most destructive disease of the season was the leaf spot, which, owing to the rainy conditions, did considerable injury to the leaves in midsummer. More extended notes have been put in the copy for a bulletin on this investigation, and if there are any other points upon which I could be of further service, I should be pleased to render that service.

The crop conditions as to stand and tonnage were very favorable in Ohio during 1900. The beets delivered to the Fremont works of the Continental Sugar Company, amounted to 21,200 tons from 2,200 acres.

Probably no additional factories will be built in Ohio during the season of 1901. Agitation has been proposed at Norwalk and Toledo.

On the experiment station grounds the tests of sugar beets were simply variety

tests. Owing to very unfavorable soil here at Wooster these results were not interesting. They are inclosed herewith.

Summary of results of analyses of sugar beets in Ohio, 1900.

County.	Number of samples.	Average weight of beets.	Sugar in beets.	Purity coefficient.
		Ounces.	*Per cent.*	
Northern section:				
Ashland	4	10.3	10.7	78.5
Cuyahoga	6	7.8	12.4	79.6
Defiance	2	5.4	13.9	83.9
Fulton	5	27.0	9.9	72.0
Hancock	1	29.1	10.9	78.1
Henry	16	11.2	13.3	82.4
Lake	4	11.1	12.9	77.0
Lorain	3	23.5	9.1	65.3
Lucas	11	12.6	11.9	81.9
Medina	22	15.3	11.7	78.5
Ottawa	1	19.5	14.8	86.7
Paulding	6	12.4	12.9	83.0
Portage	4	14.8	12.8	77.9
Putnam	12	15.1	10.2	76.2
Sandusky	17	22.6	12.9	81.6
Seneca	4	12.4	10.6	74.7
Stark	4	9.9	10.6	79.8
Summit	4	14.7	9.7	74.3
Trumbull	1	7.8	13.4	82.4
Van Wert	14	14.8	9.3	71.6
Wayne	84	8.7	10.7	77.0
Wood	1	9.8	12.1	82.5
Middle section:				
Belmont	1	6.2	14.3	83.0
Champaign	14	16.2	11.5	79.5
Clark	9	13.4	9.4	76.9
Coshocton	8	20.9	10.0	73.8
Darke	6	8.4	10.2	78.8
Delaware	4	25.0	10.0	78.0
Franklin	2	9.2	8.8	72.7
Holmes	4	20.7	13.3	81.6
Knox	2	11.4	14.5	84.2
Mercer	3	20.9	8.7	69.9
Muskingum	2	15.4	8.6	67.6
Shelby	2	9.4	12.7	80.5
Southern section:				
Fayette	2	9.7	7.5	73.9
Greene	1	9.4	9.2	69.3
Montgomery	5	23.4	8.9	66.8
Ross	4	7.0	8.9	75.2
Vinton	4	12.3	9.3	67.3
Warren	4	6.9	5.1	57.3
Summary:				
Northern section	226	12.6	11.3	77.8
Middle section	57	15.9	10.7	77.4
Southern section	20	12.5	8.1	67.5
Entire State	303	13.2	10.9	77.1

Comparison of general results for 1897, 1898, 1899, and 1900.

Section.	Number of samples.				Average weight beets in ounces.			
	1897.	1898.	1899.	1900.	1897.	1898.	1899.	1900.
Southern	67	51	20	20	31.4	18.4	21.6	12.5
Middle	132	153	18	57	32.6	19.6	23.5	15.9
Northern	355	294	93	226	29.2	25.0	20.5	12.6
Entire State	554	498	131	303	30.6	22.7	21.1	13.2

Section.	Per cent of sugar in beets.				Purity coefficient.			
	1897.	1898.	1899.	1900.	1897.	1898.	1899.	1900.
Southern	12.2	10.9	12.1	8.1	75.3	76.9	77.5	67.5
Middle	13.2	11.1	12.0	10.7	78.0	76.9	77.8	77.4
Northern	13.6	11.6	13.0	11.3	79.4	78.7	81.5	77.8
Entire State	13.3	11.4	12.7	10.9	78.7	77.9	80.2	77.1

OKLAHOMA.

Report by JOHN FIELDS, Director of Experiment Station, Stillwater, Okla., January 11, 1901.

In reply to your circular of the 5th instant, I have only to repeat my former statements concerning the possibilities of beet-sugar production in Oklahoma. The investigations of the Division of Chemistry, of experiment stations in contiguous States, and of our own experiment station all clearly show the futility of any attempt at growing sugar beets for the manufacture of sugar on a commercial scale in Oklahoma. I feel that this matter can not be stated too strongly; and general statements from official sources concerning it have been of such a nature that some of our ambitious and enterprising people have only with difficulty been prevented from launching into a beet-sugar enterprise, which would mean ruin and disaster for them and for the local agricultural interests.

The purpose of our experiments with sugar beets on the station farm during the past year was to ascertain their possibilities in providing succulent feed for our cattle and hogs during the winter months. The yield was 9¾ tons per acre. The percentage of sugar in the juice was 10 with a purity of 71.4. The seed used was that furnished by the United States Department of Agriculture.

Please say for Oklahoma that it has no possibilities to attract the beet-sugar industry. I regret it greatly, for Oklahoma grows such a great variety of crops and grows them so well that we dislike to admit the impossibility of our securing a part in this great industry that has been so largely helped by the present Secretary of Agriculture. But the results of the investigations which have shown the adaptability of other localities have shown that Oklahoma is outside of the beet-sugar belt, and it is well that the fact be at once recognized and so stated.

OREGON.

Report by A. L. KNISELY, Chemist of State Experiment Station, Corvallis, Oreg., January 16, 1901.

Your circular concerning beet industry has been referred to me. I should say the conditions were just about medium this season in Oregon, taking the State as a whole. No beets were grown at the station in 1900. The La Grande Beet Sugar Factory gives out the following:

Beets worked and sugar produced at La Grande factory, 1898–1900.

Year.	Tons of beets.	Bags of sugar.
1898	8,151	18,336
1899	11,298	22,536
1900	9,097	19,898

Newberg is working for a new factory, but there will probably be no new factories built during the next year or two.

PENNSYLVANIA.

Report by WILLIAM FREAR, Chemist of State Experiment Station, State College, Pa., January 17, 1901.

No experiments of consequence were conducted by us during the past year on the culture of the sugar beet. For several years preceding, cooperative experiments had

been conducted in different parts of the State, with the indication that both in the northern portion, where Dr. Wiley's thermal sugar-beet belt indicated that the crop could be successfully grown for sugar, and also in the lower portion, there were many localities where beets of excellent yield, richness, and purity could be obtained. These results have been confirmed by repetition, though, at least in one case, under conditions of wetness in the early season and drought in the late season, which were unfavorable to the development of the crop. It has not been thought that further work on our part at present is justified by the public interest in the sugar culture in this State.

The gentleman most interested in the study of Pennsylvania's possibilities for this industry is Mr. F. C. Bosler, an extensive landowner of Carlisle, Pa., who, several years since, was engaged in the endeavor to promote a beet-sugar manufacturing establishment to be located near Harrisburg, but I have heard nothing of this movement for a year or more, nor of any other similar movement elsewhere in the State. The facts concerning our earlier experiments are stated in bulletins of this station, from which the following extracts are made:

The general average for the State is slightly above the minimum requirements as to quality (12 per cent sugar and 80 coefficient of purity), while the yield, 15½ tons, is satisfactory.

Such averages, however, are likely to be very misleading, and a more just estimate of the bearing of the results can be obtained by a study of the several county averages. Of the 33 counties in which tests were made, 20 produced beets of satisfactory quality, and in the majority of these cases the yield was at least fairly satisfactory. In many instances, however, only one or two samples were received from a county. Results based on such a small number of trials can naturally command but little confidence. If we take the counties in which five or more trials were made, excluding Center County, where the only trials were those made on the station farm, and where the yield was very low on account of drought, we have the following results:

Results of sugar-beet experiments in ten Pennsylvania counties.

County.	Yield per acre.	Average weight of beets.	Sugar in beet.	Coefficient of purity.	Number of tests.
	Tons.	*Pounds.*	*Per cent.*		
Adams	7.50	.....	12.91	81.4	7
Bradford	13.57	1.02	13.33	82.1	5
Bucks	25.18	1.5	12.32	82.6	5
Cumberland	9.24	.....	12.08	82.0	236
Crawford	25.35	1.5	13.32	80.4	9
Franklin	8.74	.....	12.47	80.3	71
Jefferson	35.24	1.68	12.53	81.4	11
Luzerne	31.4	1.17	13.18	84.45	7
Northampton	12.96	1.98	9.36	70.0	13
Lancaster	14.43	.94	10.85	80.2	15

Of these ten counties, eight produced beets testing over 12 per cent sugar and 80 purity. Seven out of the ten also showed a yield of over 12 tons per acre.

In general, whether we consider these ten counties or the larger list, we see that the northern and northwestern counties made the best showing, both as to yield and quality. These results correspond in an interesting way with the theoretical sugar-beet belt as given in Farmers' Bulletin No. 52 of the United States Department of Agriculture.

Undoubtedly there are many instances in which the beets were harvested too early to give the best results as to quality. This affects especially Adams, Franklin, and Cumberland counties, where, in many instances, the same crop was harvested at two different dates. The averages for these counties would be raised considerably were only the later-harvested samples included.

The only decidedly adverse results were obtained in Lancaster and Northampton counties, and in the case of the former it should be noted that the results differ materially from those of 1897.

WISCONSIN.

Report by W. A. HENRY, Director of State Experiment Station, Madison, Wis., January 5, 1901.

Replying to yours of recent date I will say that we are mailing you under separate cover two copies of the seventeenth annual report of the Wisconsin Experiment Station, just coming from the press.

The factory which was partially completed at Menominee Falls, Wis., a few years since has fallen into new hands, and contracts are being made with the farmers to grow beets the present season. No beets were grown for factory purposes in this State the past year.

The following is extracted from the report referred to above:

Results of experiments with sugar beets in Wisconsin, 1890–1899.

County.	Number of years.	Number of samples.	Average size of topped beets.	Sugar in juice.	Coefficient of purity.	Yield per acre.
			Pounds.	*Per cent.*	*Per cent.*	*Tons.*
Adams	3	11	1.4	13.92	78.6	9.7
Ashland	2	7	1.5	13.91	77.6	.....
Barron	4	25	1.3	13.71	78.0	11.6
Bayfield	1	1	2.3	10.96	73.5	16.5
Brown	4	130	2.1	13.29	77.9	15.7
Buffalo	5	19	1.6	13.64	78.3	15.7
Burnett	3	6	1.4	15.14	77.6	12.5
Calumet	6	66	1.2	16.11	79.6	13.6
Chippewa	5	54	1.4	13.98	78.1	12.3
Clark	5	90	1.3	14.46	79.7	10.7
Columbia	6	55	2.0	12.92	74.7	13.4
Crawford	4	18	2.4	12.31	77.3	12.0
Dane	5	78	2.0	13.56	74.8	16.0
Dodge	5	70	1.9	13.16	76.2	16.5
Door	4	25	1.7	15.20	79.4	12.9
Douglas	3	12	1.0	15.56	83.5	16.1
Dunn	6	50	1.6	13.41	78.5	14.3
Eau Claire	3	73	1.7	11.42	75.2	12.5
Fond du Lac	5	49	2.0	12.08	73.9	13.1
Forest	3	4	1.7	11.21	72.4	10.5
Grant	4	35	2.4	10.55	70.7	13.1
Green	4	12	1.8	11.80	73.5	18.1
Green Lake	4	16	2.1	13.38	78.4	13.8
Iowa	4	12	1.7	12.91	75.4	19.9
Iron	1	1	2.2	9.96	64.7	15.5
Jackson	4	79	1.8	13.21	77.9	8.3
Jefferson	6	61	1.7	13.83	77.5	18.4
Juneau	4	18	2.3	13.69	78.1	15.8
Kenosha	5	31	1.8	13.95	77.4	21.2
Kewaunee	6	125	2.2	14.26	77.3	12.0
La Crosse	5	80	2.1	12.40	76.6	13.9
Lafayette	4	15	1.8	13.25	74.1	14.9
Langlade	2	16	1.8	12.21	76.1	17.6
Lincoln	5	18	1.0	16.32	82.7	9.6
Manitowoc	6	77	1.8	13.95	78.9	13.8
Marathon	4	62	1.4	13.49	76.3	13.5
Marinette	4	37	2.2	12.83	75.1	17.6
Marquette	4	34	1.2	14.56	80.4	14.1
Milwaukee	5	25	1.8	14.97	79.6	17.6
Monroe	5	46	1.6	13.37	76.1	11.4
Oconto	5	33	1.5	15.16	81.5	11.6
Oneida	3	8	1.4	15.23	77.3	10.6
Outagamie	5	108	2.1	13.19	77.0	19.7
Ozaukee	6	30	1.9	13.61	79.4	14.4
Pepin	5	14	2.2	16.33	81.0	16.1
Pierce	2	14	1.6	14.26	73.4	15.0
Polk	4	11	1.5	12.56	76.5	13.7
Portage	4	43	1.8	13.28	77.3	10.4
Price	3	13	1.3	13.67	74.8	8.6
Racine	5	27	2.1	14.85	79.7	18.3
Richland	4	26	1.8	12.04	71.8	14.1
Rock	5	72	1.6	14.23	78.1	14.1
St. Croix	5	54	1.4	13.69	76.9	12.1

Irrigation experiment with sugar beets at Utah Experiment Station, 1900.

Plan of irrigation.	Yield per acre.	Sugar in juice. a	Coefficient of purity. a
	Tons.	*Per cent.*	
Irrigated every week	24.03	18.6	89.1
Irrigated once in two weeks	16.03	16.0	84.9
Irrigated once in three weeks	21.40	18.0	87.8
Irrigated only when beets are badly wilted	14.70	15.2	83.6
Irrigated whenever beets are slightly wilted	15.83	14.5	81.7
Irrigated three times a week	22.40	16.9	87.0

a From analyses by Dr. J. A. Widtsoe, November 24, 1900.

After a careful review of the sugar beet crop statistics for the past three years I find the average tonnage to be 12.25 tons per acre. The analysis of the entire crop from the two factories now in operation shows an average of a little over 15 per cent sugar, with a purity of 82 per cent.

From 739 analyses, made in five different years, at the Utah Experiment Station, an average of 15.43 per cent sugar in juice and 84.85 per cent purity has been obtained.

We have no statistics at hand to show the cost of production, but the average given by many of our best beet producers is $32 per acre. Many of our farmers rent land, hire help, and then make money.

Work has already commenced on the construction of a factory at Logan, in the Cache Valley. There are 40,000 acres of land in this valley, which has been shown by the Utah Experiment Station to be adapted to the culture of sugar beets. The farmers have already contracted to grow 4,000 acres of beets. The machinery has been ordered, and it is expected to have everthing in readiness for next year's crop.

The farmers of Sanpete and Sevier counties have established the fact that their soil and climate are particularly well adapted to the sugar-beet crop and that they have 2,000 farmers ready, willing, and anxious to furnish the beets for a factory. These farmers have organized for the purpose of inviting capitalists to invest in a factory, and the indications are now that they will be successful.

Practically all the seed used in the growing of beets in America is imported from France or Germany. The Utah Sugar Company at Lehi have been successfully producing seed since 1894. During the season just closed 40 tons have been produced. This is the only company in America that has been successful in the production of seed, and they intend to increase this feature of their work until enough seed is produced to supply, at least, the Utah demand.

The outlook for the sugar beet in Utah is very promising. Here, on the small irrigated farms, with intelligent labor well directed, most gratifying results can be secured from this crop.

VIRGINIA.

Report by J. L. PHILLIPS, Assistant Entomologist, of State Experiment Station, Blacksburg, Va., January 7, 1901.

Your circular letter of December 31 in regard to sugar-beet investigation has been referred to this department, and in reply I will state that this work was discontinued several years ago on account of the many difficulties attending the same. Very few beets were grown in the State the past year and very little interest is now being taken in this line of work.

Cape Charles and Fredericksburg were agitating the establishment of factories a few years ago, but the interest has flagged, and it is not at all likely that one will be established at either place.

WISCONSIN.

Report by W. A. HENRY, Director of State Experiment Station, Madison, Wis., January 5, 1901.

Replying to yours of recent date I will say that we are mailing you under separate cover two copies of the seventeenth annual report of the Wisconsin Experiment Station, just coming from the press.

The factory which was partially completed at Menominee Falls, Wis., a few years since has fallen into new hands, and contracts are being made with the farmers to grow beets the present season. No beets were grown for factory purposes in this State the past year.

The following is extracted from the report referred to above:

Results of experiments with sugar beets in Wisconsin, 1890–1899.

County.	Number of years.	Number of samples.	Average size of topped beets.	Sugar in juice.	Coefficient of purity.	Yield per acre.
			Pounds.	*Per cent.*	*Per cent.*	*Tons.*
Adams	3	11	1.4	13.92	78.6	9.7
Ashland	2	7	1.5	13.91	77.6	.....
Barron	4	25	1.3	13.71	78.0	11.6
Bayfield	1	1	2.3	10.96	73.5	16.5
Brown	4	130	2.1	13.29	77.9	15.7
Buffalo	5	19	1.6	13.64	78.3	15.7
Burnett	3	6	1.4	15.14	77.6	12.5
Calumet	6	66	1.2	16.11	79.6	13.6
Chippewa	5	54	1.4	13.98	78.1	12.3
Clark	5	90	1.3	14.46	79.7	10.7
Columbia	6	55	2.0	12.92	74.7	13.4
Crawford	4	18	2.4	12.31	77.3	12.0
Dane	5	78	2.0	13.56	74.8	16.0
Dodge	5	70	1.9	13.16	76.2	16.5
Door	4	25	1.7	15.20	79.4	12.9
Douglas	3	12	1.0	15.56	83.5	16.1
Dunn	6	50	1.6	13.41	78.5	14.3
Eau Claire	3	73	1.7	11.42	75.2	12.5
Fond du Lac	5	49	2.0	12.08	73.9	13.1
Forest	3	4	1.7	11.21	72.4	10.5
Grant	4	35	2.4	10.55	70.7	13.1
Green	4	12	1.8	11.80	73.5	18.1
Green Lake	4	16	2.1	13.38	78.4	13.8
Iowa	4	12	1.7	12.91	75.4	19.9
Iron	1	1	2.2	9.96	64.7	15.5
Jackson	4	79	1.8	13.21	77.9	8.3
Jefferson	6	61	1.7	13.83	77.5	18.4
Juneau	4	18	2.3	13.69	78.1	15.8
Kenosha	5	31	1.8	13.95	77.4	21.2
Kewaunee	6	125	2.2	14.26	77.3	12.0
La Crosse	5	80	2.1	12.40	76.6	13.9
Lafayette	4	15	1.8	13.25	74.1	14.9
Langlade	2	16	1.8	12.21	76.1	17.6
Lincoln	5	18	1.0	16.32	82.7	9.6
Manitowoc	6	77	1.8	13.95	78.9	13.5
Marathon	4	62	1.4	13.49	76.3	13.5
Marinette	4	37	2.2	12.83	75.1	17.6
Marquette	4	34	1.2	14.56	80.4	14.1
Milwaukee	5	25	1.8	14.97	79.6	17.6
Monroe	5	46	1.6	13.37	76.1	11.4
Oconto	5	33	1.5	15.16	81.5	11.6
Oneida	3	8	1.4	15.23	77.3	10.6
Outagamie	5	108	2.1	13.19	77.0	19.7
Ozaukee	6	30	1.9	13.61	79.4	14.4
Pepin	5	14	2.2	16.33	81.0	16.1
Pierce	2	14	1.6	14.26	78.4	15.0
Polk	4	11	1.5	12.56	76.5	13.7
Portage	4	43	1.8	13.28	77.3	10.4
Price	3	13	1.3	13.67	74.8	8.6
Racine	5	27	2.1	14.85	79.7	18.3
Richland	4	26	1.8	12.04	71.8	14.1
Rock	5	72	1.6	14.23	78.1	14.1
St. Croix	5	54	1.4	13.69	76.9	12.1

Results of experiments with sugar beets in Wisconsin, 1890–1899—Continued.

County.	Number of years.	Number of samples.	Average size of topped beets.	Sugar in juice.	Coefficient of purity.	Yield per acre.
			Pounds.	*Per cent.*	*Per cent.*	*Tons.*
Sauk	5	47	1.7	13.62	76.8	13.5
Sawyer	1	1	2.9	10.69	73.8	26.1
Shawano	5	37	1.5	14.40	79.5	13.5
Sheboygan	6	89	1.8	13.64	78.0	15.6
Taylor	5	27	1.3	15.57	78.5	10.8
Trempealeau	4	61	1.5	13.12	77.0	12.0
Vernon	2	37	2.3	12.55	74.5	13.1
Vilas	3	4	1.7	16.14	81.4	.....
Walworth	5	23	1.6	14.73	79.7	15.5
Washburn	3	7	1.3	12.80	77.4	13.3
Washington	6	53	1.8	15.14	80.4	15.9
Waukesha	5	76	1.8	14.68	80.0	19.1
Waupaca	5	83	2.0	13.15	76.7	12.1
Waushara	4	35	1.6	14.34	79.4	18.0
Winnebago	6	52	2.0	13.89	78.5	14.1
Wood	5	30	1.6	14.27	79.1	11.6
Unidentified	3	15	1.5	13.44	74.7	.....
Total samples	.....	2,772	.....	.....	.....	.....

Sugar beets grown at University farm, 1899.

Variety of beets.	Plat A.		Plat B.		Plat C.		Plat D.	
	Yield of beets per acre.	Sugar in beet.	Yield of beets per acre.	Sugar in beet.	Yield of beets per acre.	Sugar in beet.	Yield of beets per acre.	Sugar in beet.
	Lbs.	*Per ct.*	*Lbs.*	*Per ct.*	*Lbs.*	*Per ct.*	*Lbs.*	*Per ct.*
Vilmorin	47,330	14.9	44,280	14.3	34,230	13.4	37,700	15.0
Zehringen	40,530	13.4	39,020	16.5	30,130	14.5	38,660	16.2
Dippe Kleinwanzlebener	40,230	15.4	39,070	16.3	28,670	15.8	32,970	16.1
Mangold	37,600	13.0	38,940	16.9	32,100	13.0	36,410	15.4
Kleinwanzlebener Braune	36,490	13.3	41,930	14.0	30,890	14.6	34,100	16.6
Kleinwanzlebener K. & S	38,550	13.5	48,630	13.7	32,910	15.6	35,180	15.4
Vilmorin Neb	38,750	14.9	41,680	15.7	32,590	15.7	38,660	16.7
Kleinwanzlebener Neb	38,470	16.2	44,620	14.6	35,940	15.1	34,360	18.0
Pitzschke	38,080	10.6	47,110	15.5	38,940	14.7	35,340	16.5
Rölker Z Z	39,600	15.7	48,960	13.8	39,310	14.6	38,870	16.5
Rölker E E	39,730	13.0	48,180	15.3	39,750	15.2	36,070	17.3
Rölker Dippe	41,690	14.6	49,030	15.2	39,430	14.9	40,310	17.0
Vilmorin	51,560	15.2	57,580	13.7	43,750	13.9	41,330	15.3
Averages and total	40,662	14.68	45,309	14.96	35,280	14.63	36,920	16.29

Variety of beets.	Plat E.		Total for whole field and for all varieties.				
	Yield of beets per acre.	Sugar in beet.	Yield of beets.		Sugar.		
			From plat.	Per acre.	From plat.	Per acre.	Per cent.
	Lbs.	*Per ct.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	
Vilmorin	37,530	16.8	3,744.3	39,300	565.9	5,937	15.11
Zehringen	29,050	16.2	1,099.3	34,830	170.8	5,411	13.53
Dippe Kleinwanzlebener	29,800	17.0	1,064.7	35,740	172.7	5,470	16.21
Mangold	28,870	16.6	1,082.4	34,300	164.8	5,220	15.23
Kleinwanzlebener Braune	28,780	17.4	1,078.6	34,020	165.6	5,247	15.43
Kleinwanzlebener K. & S	29,610	15.3	1,147.1	36,340	169.0	9,355	14.73
Vilmorin Neb	30,590	16.3	1,136.6	36,000	181.3	5,744	15.95
Kleinwanzlebener Neb	29,980	16.6	1,140.6	36,130	183.1	5,801	16.05
Pitzschke	29,150	16.2	1,167.2	36,980	187.4	5,936	16.05
Rölker ZZ	28,060	17.4	1,195.6	37,870	187.6	5,930	15.69
Rölker EE	28,790	16.1	1,185.7	37,580	185.2	6,005	15.62
Rölker Dippe	30,210	18.1	1,236.1	39,150	199.4	6,319	16.14
Vilmorin	33,060	14.9	2,747.5	43,530	398.8	6,319	14.52
Average and total	30,269	16.58	19,020.7	37,660	2,931.6	5,805	15.41

The average contents of sugar in the beet for all varieties for the different plats were as follows: Plat A, 14.68 per cent; Plat B, 14.95 per cent; Plat C, 14.63 per cent; Plat D, 16.29 per cent; and Plat E, 16.58 per cent; the average calculated yields of sugar per acre were 5,965, 6,771, 5,162, 6,013, and 5,017 pounds for Plats A, B, C, D, and E, respectively. We notice, therefore, that the yield of beets from the plat that received farmyard manure (B) was so much higher than the yields on the other plats that, in spite of the fact that these beets were considerably lower in sugar content than the beets from at least two of the other plats, the yield of sugar was increased at the rate of over 1,200 pounds per acre above the average yields for the plats not fertilized, and the yield of beets was increased at the rate of 5 tons per acre.

REPORT OF THE CHEMIST,

H. W. WILEY.

LETTER OF SUBMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
DIVISION OF CHEMISTRY,
WASHINGTON, D. C., *February 21, 1901.*

SIR: I beg to transmit herewith the tabulations of the results of analyses of sugar beets from the District of Columbia and the different States and Territories during the season of 1900.

Respectfully,

H. W. WILEY,
Chief of the Division of Chemistry.

HON. JAMES WILSON,
Secretary of Agriculture.

RESULTS OF ANALYSES OF SUGAR BEETS GROWN IN 1900.

The table following contains the results of analyses made in the laboratory of the Division of Chemistry, United States Department of Agriculture. The beets analyzed were secured from two sources: (1) The crop grown on the experimental grounds of the Department; (2) the experimental plats of individual growers scattered throughout the country to whom the Department sent sugar-beet seed. Much the greater portion came from the latter source.

The tabulations are made in the usual form, and show the number of samples received from each State and Territory, the weight of the beets, their content of sugar, the purity coefficients of the juice, and other data necessary to form an intelligent judgment concerning the character of the beets for sugar-making purposes.

The data from the different States and Territories are tabulated by counties, and the location of the county in the State is indicated. The study of these data is of great interest, as showing the character of beets grown under substantially the same cultural conditions in all parts of the United States.

382	....do	[illegible]							
856	....do	....do							
828	....do	Thornton	P. M. Stegeman						
276	Johnson	Goreville	J. C. Trovillion						
956	Kane	Elgin	P. Whipple						
144	Morgan	Nortonville	E. L. Whittock	Vilmorin's Improved				68.6	Yes.
602	Randolph	Schuline	H. C. Hagen	....do	Oct. 19	15	7.3	64.2	No.
207	St. Clair	Millstadt	N. Rohr		Sept. 9	13	5.7	30.5	Yes.
874	Warren	Monmouth	E. C. Linn		Nov. 10	25	6.4	59.3	Yes.
	State averages (16 samples).					27	8.3	65.2	
	INDIANA.								
346	Elkhart	Elkhart	B. F. Oakes	Vilmorin's Improved	Sept. 26	27	12.1	79.9	No.
533	Henry	Lewisville	J. Parker		Oct. 8	7	9.1	71.1	Yes.
126	Knox	Fritchton	E. Snaw	Strandes' Zehringen	Sept. 3	31	7.1	65.8	No.
598	Laporte	Laporte	E. Rechenberg	Vilmorin's Improved	Oct. 20	26	6.9	60.8	Yes.
817	....do	....do	....do	....do	Nov. 3	21	9.1	69.1	Yes.
378	Marshall	Tyner	M. Chase	Kleinwanzlebener (Dippe)	Sept. 30	18	7.9	70.3	Yes.
582	Noble	Rome City	G. A. Stroup, M. D.	Vilmorin's Improved	Oct. 17	16	10.7	79	Yes.
328	Pulaski	Medaryville	G. Hansen	....do	Sept. 24	15	9.3	66.2	No.
850	Ripley	Crossplains	J. Vanosdal	....do	Nov. 5	12	10.1	71.6	Yes.

Results of analyses of sugar beets at the chemical laboratory of the Department of Agriculture during the year 1900, by States—Continued.

Serial number.	State or Territory and county.	Where grown.	Plot.	Variety.	When harvested.	Average weight.	Sugar in the beet.	Purity coefficient.
	DISTRICT OF COLUMBIA—continued.							
.....	District of Columbia.....	Experimental grounds, Department of Agriculture.	Plot No. 507.....	S. P. I. 3943, Kleinwanzlebener (Miozinski).	Oct. 9	*Ounces.* 12.6	*Per cent.* 8	67.2
.....	.....do.....	.....do.....	.....do.....	.....do.....	Oct. 15	11.2	7.8	65.6
.....	.....do.....	.....do.....	.....do.....	.....do.....	Oct. 22	15.2	7.4	66.7
.....	.....do.....	.....do.....	.....do.....	.....do.....	Oct. 30	14.1	7.4	67.2
.....	.....do.....	.....do.....	.....do.....	.....do.....	Nov. 6	16.1	7.3	67.5
.....	.....do.....	.....do.....	.....do.....	.....do.....	Nov. 13	16.1	6.6	62.2
.....	.....do.....	.....do.....	.....do.....	.....do.....	Nov. 19	8.9	7.5	65.8
.....	.....do.....	.....do.....	.....do.....	.....do.....	Nov. 27	12.2	7.5	64.2
.....	.....do.....	.....do.....	.....do.....	.....do.....	Dec. 3	23.2	8	66.7
.....	.....do.....	.....do.....	.....do.....	.....do.....	Dec. 11	11.7	9.3	73.1
	Averages for this variety (13 samples).	.....	.....	.....	.....	13.5	8	67.4

Results of analyses of sugar beets in the chemical laboratory of the Department of Agriculture during the year 1900, by States.

[The symbol following name of county indicates the location of the county within the State, as follows: □, central; ⊓, northern; □-, eastern; ⊔, southern; -□, western; ⊓, northwestern; ◰, northeastern; □, southeastern; ◱, southwestern.]

Serial number.	State or Territory and county.	Post-office.	Experimenter.	Variety.	When harvested.	Average weight.	Sugar in the beet.	Purity coefficient.	Was season favorable?
	GEORGIA.								
266	Forsyth ⊓	Storeville	J. H. Jones.....	Kleinwanzlebener (Dippe).....	Sept. 14	*Ounces.* 10	*Per cent.* 14.2	86.6	No.
	State averages (1 sample).	.....	.....	.....	.....	10	14.2	86.6	
	IDAHO.								
535	Bingham □	Iona.....	C. W. Rockwood	Vilmorin's Improved.....	Oct. 8	80	12.8	88.2	Yes.
536	.....do.....	.....do.....	.....do.....	Kleinwanzlebener	.....do ..	50	10.6	64.9	Yes.
148	Canyon □	Caldwell	J. A. Walker	Vilmorin's Improved	Sept. 5	20	12.7	77.9	Yes.
5 11	.....do.....	.....do.....	.....do.....	.....do.....	Oct. 5	11	10.9	84.3	Yes.

364	Fremont	Parker	J. Horner		Sept. 27	25	15.7	82.7	Yes.
362	do	St. Anthony	C. E. Miller		Sept. 29	12	14.5	83.6	No.
356	do	Wilford	G. A. Pincock	Kleinwanzlebener (Dippe)	Sept. 24	18	12.5	78.6	No.
341	do	Tilton	J. M. Baker	do	do	33	16.9	88.1	Yes.
590	do	Rexburg	H. Picks	do	Oct. 15	32	14.4	80.8	Yes.
513	do	Parker	J. T. B. Mason	do	Oct. 6	20	13.8	86.8	Yes.
566	do	Rexburg	C. Keppner	do	Oct. 12	46	10.2	74.8	Yes.
545	do	Edmunds	R. Hamsley		Oct. 8	7	14.8		Yes.
775	do	do	do		Oct. 23	16	15.4	87.1	No.
741	do	Rexburg	T. Bassett		Sept. 19	63	11.5	79.6	Yes.
714	do	do	J. A. Stephens	Kleinwanzlebener	Oct. 20	9	12.5	83.4	Yes.
964	do	St. Anthony	C. E. Miller	Kleinwanzlebener (Mrozinski)	Oct. 28	21	11.3	79.9	Yes.
971	do	do	do	do	Nov. 20	6	15.6	90.6	Yes.
957	Idaho	Ferdinand	P. Aschenbremen	Vilmorin's Improved	Nov. 16	29	13.4	77.9	Yes.
959	do	do	do	do	do	21	13.6	76.9	Yes.
	State averages (19 samples).					26	13.5	81.4	
	ILLINOIS.								
324	Champaign	Rantoul	H. B. Clark	Vilmorin's Improved	Sept. 24	52	4.7	53.8	Yes.
328	do	do	do	do	do	41	5.7	59.4	Yes.
532	Clinton	New Memphis	J. G. Loschert		Oct. 10	32	8.4	68.2	Yes.
550	do	do	do		do	34	7.4		Yes.
296	Cook	Harvey	W. J. Massingham	Kleinwanzlebener (Dippe)	Sept. 17	16	6.9	65.2	Yes.
348	do	do	do	do	Sept. 27	11	8.8	69	Yes.
552	do	South Holland	C. Dalenberg	do	Oct. 10	50	11	73.9	Yes.
592	do	Oak Glen	J. Riefeld	Vilmorin's Improved	Oct. 16	19	10.7	72.5	Yes.
856	do	do	do	do	Nov. 6	17	12.9	79.1	Yes.
828	do	Thornton	P. M. Stegenga	Kleinwanzlebener	Nov. 5	12	12.5	79	Yes.
276	Johnson	Goreville	J. C. Trovillion		Sept. 17	28	6.3	62.8	No.
956	Kane	Elgin	P. Whipple		Nov. 28	43	10.6	73.2	
144	Morgan	Nortonville	E. L. Whittock	Vilmorin's Improved	Sept. 6	23	6.8	68.6	Yes.
602	Randolph	Schuline	H. C. Hagen	do	Oct. 19	15	7.3	64.2	No.
207	St. Clair	Millstadt	N. Rohr		Sept. 9	13	5.7	30.5	Yes.
874	Warren	Monmouth	E. C. Linn		Nov. 10	25	6.4	59.3	Yes.
	State averages (16 samples).					27	8.3	65.2	
	INDIANA.								
346	Elkhart	Elkhart	B. F. Oakes	Vilmorin's Improved	Sept. 26	27	12.1	79.9	No.
533	Henry	Lewisville	J. Parker		Oct. 8	7	9.1	71.1	Yes.
126	Knox	Fritchton	E. Shaw	Strandes' Zehringen	Sept. 3	31	7.1	65.8	No.
598	Laporte	Laporte	E. Rechenberg	Vilmorin's Improved	Oct. 20	26	6.9	60.8	Yes.
817	do	do	do	do	Nov. 3	21	9.1	69.1	Yes.
378	Marshall	Tyner	M. Chase	Kleinwanzlebener (Dippe)	Sept. 30	18	7.9	70.3	Yes.
582	Noble	Rome City	G. A. Stroup, M. D.	Vilmorin's Improved	Oct. 17	16	10.7	79	Yes.
328	Pulaski	McCaryville	G. Hansen	do	Sept. 24	15	9.3	66.2	No.
830	Ripley	Crossplains	J. Vanosdal	do	Nov. 5	12	10.1	71.6	Yes.

Results of analyses of sugar beets in the chemical laboratory of the Department of Agriculture during the year 1900, by States—Continued.

[The symbol following name of county indicates the location of the county within the State, as follows: □, central; ⌂, northern; □-, eastern; ⍗, southern; -□, western; ⌂, northwestern; ◰, northeastern; ◱, southeastern; ◲, southwestern.]

Serial number.	State or Territory and county.	Post-office.	Experimenter.	Variety.	When harvested.	Average weight.	Sugar in the beet.	Purity coefficient.	Was season favorable?
	INDIANA—continued.								
						Ounces.	*Per cent.*		
259	Shelby □	Morristown	A. V. Wagoner	Vilmorin's Improved	Sept. 14	23	8.8	71	Yes.
724	do	Waldron	Wm. R. Neuton		Oct. 25	37	5.7	52.6	Yes.
515	Starke ⌂	San Pierre	Mrs. P. Kramer	Vilmorin's Improved	Oct. 8	15	11.3	82	Yes.
683	Steuben ◰	Ray	B. J. Bohner	do	Oct. 22	31	11.3	76.8	Yes.
648	do	do	do	do	do	27	13	79.7	Yes.
471	Wabash ⌂	Roann	W. P. Carpender	do	Sept. 4	10	8.6	70	Yes.
	State averages (15 samples).					21	9.4	71.1	
	INDIAN TERRITORY.								
123	Cherokee Nation ⌂	Stilwell	L. Davis	Vilmorin's Improved	Sept. 1	6	11	81.1	No.
320	Chickasaw Nation ◲	Leon	R. M. Brown	Strandes' Zehringen	Sept. 16	30	7.2	63.8	No.
129	Choctaw Nation ⍗	Durant	K. R. Underwood	Kleinwanzlebener (Dippe)	Sept. 3	51	5.5	53.7	Yes.
	Averages (3 samples)					29	7.9	66.2	
	IOWA.								
433	Adams ◱	Prescott	C. S. Crouse	Vilmorin's Improved	Oct. 3	32	7.5	52.7	No.
340	Allamakee ◰	Waukon	A. C. Johnson	Kleinwanzlebener (Dippe)	Sept. 24	26	8.6	70	Yes.
372	do	Ion	C. Kelly		Sept. 30	32	10.8	76	No.
600	Boone □	Boone	J. S. Friedley	Strandes' Zehringen	Oct. 17	44	9.3	70	No.
653	Cerro Gordo ⌂	Mason City	J. P. Calom	Vilmorin's Improved	Oct. 22	41	9.2	63	Yes.
651	do	do	T. Butts	do	do	57	9.5		Yes.
269	Cherokee ⌂	Cherokee	W. M. Little		Sept. 15	15	8.8	72.1	No.
360	do	do	Z. Wellman	Vilmorin's Improved	Sept. 29	27	9	71.4	No.
205	Clayton ◰	Gunder	R. Southwell	Kleinwanzlebener (Dippe)	Sept. 10	26	9.1	71.6	No.
298	do	Guttenberg	E. Goetz	Vilmorin's Improved	Sept. 20	13	7.6	67.2	No.
287	do	Updegraff	L. A. Oldham	do	Sept. 17	22	13	77.9	Yes.
309	do	Gunder	R. Southwell	Kleinwanzlebener (Dippe)	Sept. 20	30	10.1	72.6	No.
345	do	Garnavillo	A. Kregel	Vilmorin's Improved	Sept. 26	19	9.9	71.7	Yes.
860	do	do	E. W. Koegel	do	Nov. 5	64	10.1	73.6	No.
863	do	do	do	do	do	58	10.5	74.8	No.
877	do	do	H. Schlake	do	Nov. 10	33	8.3	60.9	Yes.
853	Crawford -□	Dow City	Wm. Jenkins		Sept. 24	33	6.1	60.9	Yes.
382	do	do	do		do	28	8.5	60	Yes.
483	Fayette ◰	Hawkins	E. E. Bonnin	Kleinwanzlebener	Sept. 6	23	9.1	60.6	Yes.

818	Franklin	Sheffield	B. Thrassel	do	Nov. 2	24	9.7	72.9	No.
349	Hancock	Goodell	J. B. Cundiff	Kleinwanzlebener (Dippe)	Sept. 28	46	9.4	69.2	Yes.
591	do	Butt	J. E. Gifford	do	Oct. 16	27	10.7	72.9	No.
804	Jackson	Sabula	Selber & Simpson		Oct. 27	32	6.4	61.9	No.
810	Marion	Tracy	W. K. Rouze	Kleinwanzlebener	Nov. 3	12	7.5	63.4	No.
728	Montgomery	Stanton	A. Trabert	Vilmorin's Improved	Oct. 24	27	8.8	67.9	No.
527	Sac	Early	F. Tank		Oct. 9	24	8.5	70	Yes.
589	Shelby	Irwin	G. E. Stevenson	Vilmorin's Improved	Oct. 16	16	9.7	74.5	No.
871	Story	Ames Express Station.	J. Atkinson	Kleinwanzlebener (Australian Special).	Nov. 6	13	11.7	76.9	-
339	Webster	Moorland	L. H. Fiala		Sept. 24	40	9.3	71.5	Yes.
479	do	Fort Dodge	P. J. Schultz		Oct. 1	50	7.7	64.8	Yes.
616	do	Badger	A. Chaulland	Knauer's Mangold	Oct. 17	20	14.4	82.1	No.
757	do	Fort Dodge	Becker Bros	do	Oct. 23	32	11.5	78	No.
792	do	do	L. W. Neudick		Oct. 29	28	10.8	74	Yes.
910	do	Moorland	J. H. Fiala		Nov. 1	24	12.4	79.8	Yes.
770	Winnebago	Buffalo Center	C. E. Mallory		Oct. 25	65	9.7	73.9	No.
811	do	Lake Mills	T. J. Helgensen		Nov. 3	42	10	71.4	No.
274	Winneshiek	Castalia	A. H. Upley		Sept. 18	46	8.3	71.9	No.
336	do	Spillville	A. Roidor		Sept. 23	15	10.6	76.6	No.
892	Worth	Grafton	G. Kruger		Nov. 1	90	6.3	61.1	No.
	State averages (39 samples).					33	9.5	70.7	
	KANSAS.								
275	Allen	Laharpe	E. D. Kramer	Kleinwanzlebener (Dippe)	Sept. 17	41	12.6	72.6	Yes.
962	do	do	do	do	Nov. 24	35	12	75	No.
71	Bourbon	Fort Scott	W. C. Gunn	do	Aug. 10	22	10.9	68	No.
321	do	Godfrey	A. Hurley	Vilmorin's Improved	Sept. 22	13	9.9	74.3	No.
551	do	Fort Scott	H. E. Russell	Kleinwanzlebener	Oct. 9	17	8.8	71.5	Yes.
573	do	Godfrey	A. Hunley	Vilmorin's Improved	Oct. 13	11	10.5	76.9	Yes.
876	do	do	do	do	Nov. 9	16	9.6	71.1	Yes.
878	do	Fort Scott	L. Schlinger	do	do	28	8.8	22.4	Yes.
953	do	do	W. C. Gunn	Kleinwanzlebener	Nov. 10	9	12.5	78.9	No.
955	do	do	H. W. Hughes	do	do	13	8.2	67.7	No.
950	do	do	Ira Moore	do	do	18	8.9	64.8	No.
581	Decatur	Bassettville	O. P. Ecord	do	Oct. 15	39	11.9	74.5	No.
145	Ellsworth	Ellsworth	J. Morton	Kleinwanzlebener (Dippe)	Sept. 8	20	8.9	68.6	No.
281	Johnson	Olathe	S. F. West	do	Sept. 18	43	6.3	57.9	Yes.
170	Leavenworth	Mount Olivet	F. W. Toff	Vilmorin's Improved	Sept. 11	21	9.7	76.7	No.
782	Marshall	Marysville	J. Seematler	Kleinwanzlebener	Oct. 27	46	11.4	75.9	No.
819	do	do	do	do	Nov. 2	39	11.3	74.9	No.
914	do	Bremen	J. Stohs		Nov. 17	27	8.4	67.2	Yes.
609	Stevens	Hugoton	M. Traver	Kleinwanzlebener	Oct. 15	2	7.6		Yes.
742	Washington	Hanover	H. Huehring	do	Oct. 25	30	13	81.1	Yes.
	State averages (20 samples).					25	10.1	72.1	

364	Fremont	Parker	J. Horner		Sept. 27	23	16.1	87.1	
362	do	St. Anthony	C. E. Miller		Sept. 29	12	14.5	83.6	No.
356	do	Wilford	G. A. Pincock	Kleinwanzlebener (Dippe)	Sept. 24	18	12.5	78.6	No.
341	do	Tilton	J. M. Baker	do	do	33	16.9	88.1	Yes.
590	do	Rexburg	H. Picks	do	Oct. 15	32	14.4	80.8	Yes.
513	do	Parker	J. T. B. Mason	do	Oct. 6	20	13.8	86.8	Yes.
566	do	Rexburg	C. Keppner	do	Oct. 12	46	10.2	74.8	Yes.
545	do	Edmunds	R. Hamsley		Oct. 8	7	14.8		Yes.
775	do	do	do		Oct. 23	16	15.4	87.1	No.
741	do	Rexburg	T. Bassett		Sept. 19	63	11.5	79.6	Yes.
714	do	do	J. A. Stephens	Kleinwanzlebener	Oct. 20	9	12.5	83.4	Yes.
964	do	St. Anthony	C. E. Miller	Kleinwanzlebener (Mrozinski)	Oct. 28	21	11.3	79.9	Yes.
971	do	do	do	do	Nov. 20	6	15.6	90.6	Yes.
957	Idaho	Ferdinand	P. Aschenbremen	Vilmorin's Improved	Nov. 16	29	13.4	77.9	Yes.
959	do	do	do	do	do	21	13.6	76.9	Yes.
	State averages (19 samples).					26	13.5	81.4	
	ILLINOIS.								
324	Champaign	Rantoul	H. B. Clark	Vilmorin's Improved	Sept. 24	52	4.7	53.8	Yes.
323	do	do	do	do	do	41	5.7	59.4	Yes.
582	Clinton	New Memphis	J. G. Loschert		Oct. 10	32	8.4	68.2	Yes.
550	do	do	do		do	34	7.4		Yes.
296	Cook	Harvey	W. J. Massingham	Kleinwanzlebener (Dippe)	Sept. 17	16	6.9	65.2	Yes.
348	do	do	do	do	Sept. 27	11	8.8	69	Yes.
552	do	South Holland	C. Dalenberg	do	Oct. 10	50	11	73.9	Yes.
592	do	Oak Glen	J. Riefeld	Vilmorin's Improved	Oct. 16	19	10.7	72.5	Yes.
856	do	do	do	do	Nov. 6	17	12.9	79.1	Yes.
828	do	Thornton	P. M. Stegenga	Kleinwanzlebener	Nov. 5	12	12.5	79	Yes.
276	Johnson	Goreville	J. C. Trovillion		Sept. 17	23	6.3	62.8	No.
956	Kane	Elgin	P. Whipple		Nov. 28	43	10.6	73.2	
144	Morgan	Nortonville	E. L. Whittock	Vilmorin's Improved	Sept. 6	23	6.8	68.6	Yes.
602	Randolph	Schuline	H. C. Hagen	do	Oct. 19	15	7.3	64.2	No.
207	St. Clair	Millstadt	N. Rohr		Sept. 9	13	5.7	30.5	Yes.
874	Warren	Monmouth	E. C. Linn		Nov. 10	25	6.4	59.3	Yes.
	State averages (16 samples).					27	8.3	65.2	
	INDIANA.								
346	Elkhart	Elkhart	B. F. Oakes	Vilmorin's Improved	Sept. 26	27	12.1	79.9	No.
533	Henry	Lewisville	J. Parker		Oct. 8	7	9.1	71.1	Yes.
126	Knox	Fritchton	E. Snaw	Strandes' Zehringen	Sept. 3	31	7.1	65.8	No.
598	Laporte	Laporte	E. Rechenberg	Vilmorin's Improved	Oct. 20	26	6.9	60.8	Yes.
817	do	do	do	do	Nov. 3	21	9.1	69.1	Yes.
378	Marshall	Tyner	M. Chase	Kleinwanzlebener (Dippe)	Sept. 30	18	7.9	70.3	Yes.
582	Noble	Rome City	G. A. Stroup, M. D.	Vilmorin's Improved	Oct. 17	16	10.7	79	Yes.
328	Pulaski	Medaryville	G. Hansen	do	Sept. 24	15	9.3	66.2	No.
830	Ripley	Crossplains	J. Vanosdal	do	Nov. 5	12	10.1	71.6	Yes.

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Serial number.	State or Territory and county.	Post-office.	Experimenter.	Variety.	When harvested.	Average weight.	Sugar in the beet.	Purity coefficient.	Was season favorable?
	INDIANA—continued.								
						Ounces.	*Per cent.*		
259	Shelby □	Morristown	A. V. Wagoner	Vilmorin's Improved	Sept. 14	23	8.8	71	Yes.
724	....do	Waldron	Wm. R. Neuton		Oct. 25	37	5.7	52.6	Yes.
515	Starke ⌜□	San Pierre	Mrs. P. Kramer	Vilmorin's Improved	Oct. 8	15	11.3	82	Yes.
683	Steuben ⌝□	Ray	B. J. Bohner	....do	Oct. 22	31	11.3	76.8	Yes.
648	....do	....do	....do	....do	....do	27	13	79.7	Yes.
471	Wabash ⌂	Roann	W. P. Carpender	....do	Sept. 4	10	8.6	70	Yes.
	State averages (15 samples).					21	9.4	71.1	
	INDIAN TERRITORY.								
123	Cherokee Nation ⌂	Stilwell	L. Davis	Vilmorin's Improved	Sept. 1	6	11	81.1	No.
320	Chickasaw Nation □	Leon	R. M. Brown	Strandes' Zehringen	Sept. 16	30	7.2	63.8	No.
129	Choctaw Nation ⍗	Durant	K. R. Underwood	Kleinwanzlebener (Dippe)	Sept. 3	51	5.5	53.7	Yes.
	Averages (3 samples)					29	7.9	66.2	
	IOWA.								
433	Adams □	Prescott	C. S. Crouse	Vilmorin's Improved	Oct. 3	32	7.5	52.7	No.
340	Allamakee ⌝□	Waukon	A. C. Johnson	Kleinwanzlebener (Dippe)	Sept. 24	28	8.6	70	Yes.
372	....do	Ion	C. Kelly		Sept. 30	32	10.8	76	No.
600	Boone □	Boone	J. S. Friedley	Strandes' Zehringen	Oct. 17	44	9.3	70	No.
653	Cerro Gordo ⌂	Mason City	J. P. Calom	Vilmorin's Improved	Oct. 22	41	9.2	63	Yes.
651	....do	....do	T. Butts	....do	....do	57	9.5		Yes.
269	Cherokee ⌜□	Cherokee	W. M. Little		Sept. 15	15	8.8	72.1	No.
360	....do	....do	Z. Wellman	Vilmorin's Improved	Sept. 29	27	9	71.4	No.
205	Clayton ⌝□	Gunder	R. Southwell	Kleinwanzlebener (Dippe)	Sept. 10	26	9.1	71.6	No.
298	....do	Guttenberg	E. Goetz	Vilmorin's Improved	Sept. 20	13	7.6	67.2	No.
287	....do	Updegraff	L. A. Oldham	....do	Sept. 17	22	13	77.9	Yes.
309	....do	Gunder	R. Southwell	Kleinwanzlebener (Dippe)	Sept. 20	30	10.1	72.6	No.
345	....do	Garnavillo	A. Kregel	Vilmorin's Improved	Sept. 26	19	9.9	71.7	Yes.
850	....do	....do	E. W. Koegel	....do	Nov. 5	64	10.1	73.6	No.
853	....do	....do	....do	....do	....do	58	10.5	74.8	No.
877	....do	....do	H. Schlake	....do	Nov. 10	33	8.3	66.9	Yes.
353	Crawford ⌝□	Dow City	Wm. Jenkins		Sept. 24	33	6.4	60.9	Yes.
352	....do	....do	....do		....do	28	8.5	69	Yes.
483	Fayette ⌝□	Hawkins	B. S. Bennin	Kleinwanzlebener	Sept. 5	23	9.1	69.6	Yes.

818	Franklin	Sheffield	B. Thrassel	do	Nov. 2	24	9.7	72.9	No.
349	Hancock	Goodell	J. B. Cundiff	Kleinwanzlebener (Dippe)	Sept. 28	46	9.4	69.2	Yes.
591	do	Butt	J. E. Gifford	do	Oct. 16	27	10.7	72.9	No.
804	Jackson	Sabula	Seiber & Simpson		Oct. 27	32	6.4	61.9	No.
810	Marion	Tracy	W. K. Rouze	Kleinwanzlebener	Nov. 3	12	7.5	63.4	No.
728	Montgomery	Stanton	A. Trabert	Vilmorin's Improved	Oct. 24	27	8.8	67.9	No.
527	Sac	Early	F. Tank		Oct. 9	24	8.5	70	Yes.
589	Shelby	Irwin	G. E. Stevenson	Vilmorin's Improved	Oct. 16	16	9.7	74.5	No.
871	Story	Ames Express Station.	J. Atkinson	Kleinwanzlebener (Australian Special).	Nov. 6	13	11.7	76.9	
339	Webster	Moorland	L. H. Fiala		Sept. 24	40	9.3	71.5	Yes.
479	do	Fort Dodge	P. J. Schultz		Oct. 1	50	7.7	64.8	Yes.
616	do	Badger	A. Chaulland	Knauer's Mangold	Oct. 17	20	14.4	82.1	No.
757	do	Fort Dodge	Becker Bros	do	Oct. 23	32	11.5	78	No.
792	do	do	L. W. Neudick		Oct. 29	28	10.8	74	Yes.
910	do	Moorland	J. H. Fiala		Nov. 1	24	12.4	79.8	Yes.
770	Winnebago	Buffalo Center	C. E. Mallory		Oct. 25	65	9.7	73.9	No.
811	do	Lake Mills	T. J. Helgensen		Nov. 3	42	10	71.4	No.
274	Winneshiek	Castalia	A. H. Upley		Sept. 18	46	8.3	71.9	No.
336	do	Spillville	A. Roidor		Sept. 23	15	10.6	76.6	No.
892	Worth	Grafton	G. Kruger		Nov. 1	90	6.3	61.1	No.
	State averages (39 samples).					33	9.5	70.7	
	KANSAS.								
275	Allen	Laharpe	E. D. Kramer	Kleinwanzlebener (Dippe)	Sept. 17	41	12.6	72.6	Yes.
962	do	do	do	do	Nov. 24	35	12	75	No.
71	Bourbon	Fort Scott	W. C. Gunn	do	Aug. 10	22	10.9	68	No.
321	do	Godfrey	A. Hurley	Vilmorin's Improved	Sept. 22	13	9.9	74.3	No.
551	do	Fort Scott	H. E. Russell	Kleinwanzlebener	Oct. 9	17	8.8	71.5	Yes.
573	do	Godfrey	A. Hunley	Vilmorin's Improved	Oct. 13	11	10.5	76.9	Yes.
876	do	do	do	do	Nov. 9	16	9.6	71.1	Yes.
878	do	Fort Scott	L. Schlinger	do	do	28	8.8	22.4	Yes.
953	do	do	W. C. Gunn	Kleinwanzlebener	Nov. 10	9	12.5	78.9	No.
955	do	do	H. W. Hughes	do	do	13	8.2	67.7	No.
950	do	do	Ira Moore	do	do	18	8.9	64.8	No.
581	Decatur	Bassettville	O. P. Ecord	do	Oct. 15	39	11.9	74.5	No.
145	Ellsworth	Ellsworth	J. Morton	Kleinwanzlebener (Dippe)	Sept. 8	20	8.9	68.6	No.
281	Johnson	Olathe	S. F. West	do	Sept. 18	43	6.3	57.9	Yes.
170	Leavenworth	Mount Olivet	F. W. Toff	Vilmorin's Improved	Sept. 11	21	9.7	76.7	No.
782	Marshall	Marysville	J. Seematter	Kleinwanzlebener	Oct. 27	46	11.4	75.9	No.
819	do	do	do	do	Nov. 2	39	11.3	74.9	No.
914	do	Bremen	J. Stohs		Nov. 17	27	8.4	67.2	Yes.
609	Stevens	Hugoton	M. Traver	Kleinwanzlebener	Oct. 15	2	7.6		Yes.
742	Washington	Hanover	H. Huehring	do	Oct. 25	30	13	81.1	Yes.
	State averages (20 samples).					25	10.1	72.1	

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Serial number.	State or Territory and county.	Post-office.	Experimenter.	Variety.	When harvested.	Average weight.	Sugar in the beet.	Purity coefficient.	Was season favorable?
	KENTUCKY.					*Ounces.*	*Per cent.*		
940	Fayette □	Lexington	Kentucky Agricultural Experiment Station.	Kleinwanzlebener (Mrozinski)	Nov. 19	9	8.5	69	Yes.
941	.....do	.....do	.....do	Licht's Zuckerreichste	.....do	9	8.8	70.4	Yes.
945	.....do	.....do	.....do	Vilmorin's Improved	.....do	9	9.1	70.6	Yes.
929	.....do	.....do	.....do	Kleinwanzlebener	.....do	9	10.9	75.2	Yes.
933	.....do	.....do	.....do	Strandes' Zehringen	.....do	12	10	77.2	Yes.
937	.....do	.....do	.....do	White Queen of the North	.....do	10	8.6	73.2	Yes.
939	.....do	.....do	.....do	Kleinwanzlebener (Austrian Special).	.....do	9	7.9	68	Yes.
733	Grayson -□	Falls of Rough	R. C. Beauchamp	Kleinwanzlebener	Oct. 23	3	9.3	.....	No.
406	Nelson □	Highgrove	D. P. Stallard		Oct. 2	40	5.1	27.1	Yes.
319	Warren □	Bowling Green	M. M. Ennis	Kleinwanzlebener (Dippe)	Sept. 21	13	10	75.5	No.
318	.....do	.....do	.....do	.....do	.....do	18	9.5	74.1	No.
133	.....do	.....do	D. Handy	Strandes' Zehringen	Sept. 5	12	3.8	32.8	Yes.
	State averages (12 samples).					13	8.5	64.8	
	MAINE.								
391	Penobscot □	Hampden Corner	R. W. Muldi		Sept. 29	18	9.1	72.2	Yes.
392	.....do	.....do	.....do		.....do	20	7	63.2	Yes.
	State averages (2 samples).					19	8.1	67.7	
	MARYLAND.								
815	St. Mary □	Beauvue	G. F. Dyer		Nov. 1	10	9.3	74.2	No.
	State averages (1 sample).					10	9.3	74.2	
	MASSACHUSETTS.								
908	Plymouth □	Plymouth	E. E. Avery	Vilmorin's Improved	Nov. 15	9	13.9	.....	Yes.
907	.....do	.....do	.....do	Kleinwanzlebener	Nov. 16	6	14.1	.....	No.
	State averages (2 samples).					8	11	.....	

	MICHIGAN.								
698	Allegan	Hilliards	W. C. Miles	Kleinwanzlebener	Oct. 23	22	12.8	79	Yes.
837	....do	....do	....do	....do	....do	21	12	80.8	Yes.
790	Antrim	Bellaire	O. B. Orcutt	....do	Oct. 30	31	14	82.1	Yes.
710	Barry	Woodland	J. H. Sawdy	....do	Oct. 23	42	10	68.6	Yes.
732	Bay	Loehne	E. Loehne	....do	Oct. 24	43	12.9	82.4	Yes.
806	Benzie	Nessen City	C. F. Pulsifer	Vilmorin's Improved	Sept. 21	18	11.7	79.9	Yes.
801	....do	Lake Ann	W. F. Shutt	Kleinwanzlebener	Oct. 31	26	13.2	80.8	Yes.
849	....do	Benzonia	E. B. Judson		Nov. 6	23	11.2	72.4	Yes.
987	Berrien	Threecoaks	A. Sherwood	Kleinwanzlebener	Dec. 8	23	10.4	77.9	No.
416	Calhoun	Bedford	C. F. Booker	Strandes' Zehringen	Oct. 2	16	10.7	72.5	Yes.
474	....do	....do	R. Willard	Vilmorin's Improved	....do	23	7.1	61.5	Yes.
377	Charlevoix	Boyne	Van R. Nervoille	Kleinwanzlebener (Mrozinski)	Sept. 30	27	8.6	68.7	Yes.
571	Gratiot	Sickels	A. L. Wight	Vilmorin's Improved	Oct. 15	14	12.3	78.2	No.
524	Iron	Iron River	J. S. Kinney		....do	29	11.9	78.7	Yes.
574	Isabella	Weidman	A. A. Smith	Vilmorin's Improved	....do	25	12.7	80.2	Yes.
912	Lapeer	Dryden	Wm. Dittman	....do	Nov. 9	30	10.7	79	Yes.
157	Lenawee	Ridgeway	C. S. Foote	Strandes' Zehringen	Sept. 11	15	9.7	72.3	Yes.
249	....do	Tecumseh Township	D. T. Hall	Vilmorin's Improved	....do	14	13.2	79.4	Yes.
247	....do	Clinton Township	D. R. Gibson	Kleinwanzlebener (Dippe)	....do	10	10.6	75.2	Yes.
248	....do	Tecumseh Township	D. T. Hall	....do	....do	12	12.8	81.3	Yes.
432	....do	Clinton Township	D. R. Gibson	....do	Oct. 2	12	10	69.5	Yes.
454	....do	Tecumseh Township	D. T. Hall	....do	Oct. 3	31	10.6	71.3	Yes.
523	....do	Rollin	G. W. Belcher	Kleinwanzlebener	Oct. 2	32	6.9	63.4	Yes.
700	....do	Ridgeway	C. S. Foote	Strandes' Zehringen	Oct. 23	19	12.1	79.4	Yes.
628	....do	Clinton	D. R. Gibson	Kleinwanzlebener	....do	14	11.6	76.7	Yes.
629	....do	Blissfield	H. G. Clark	....do	Oct. 22	12	12.8	80.9	Yes.
747	....do	Palmyra	C. P. Palmer	....do	Oct. 27	18	12.2	81	No.
740	....do	....do	....do	Vilmorin's Improved	....do	22	11	75.8	No.
786	....do	Blissfield	W. H. Colyer	....do	Oct. 19	9	9.4	71.2	No.
787	....do	....do	....do	....do	Oct. 17	18	9.4	69.7	No.
864	....do	Britton	G. W. Smith	....do	Oct. 23	24	12.5	80	No.
893	....do	Palmyra	G. P. Palmer	Strandes' Zehringen	Nov. 14	17	11.2	74.7	No.
902	....do	....do	....do	Kleinwanzlebener	....do	9	12.3	78.7	No.
611	Macomb	Mount Vernon	C. L. Lockwood		Oct. 20	54	8.1	62.9	
816	Manistee	Pierport	G. F. Beaver	Vilmorin's Improved	Oct. 30	16	13	83	No.
879	Mecosta	Rodney	W. F. Zehnzen	Kleinwanzlebener	Nov. 6	20	10.1	70.2	Yes.
881	....do	Titus	E. Scheibe	Vilmorin's Improved	Nov. 9	50	12.3	80.1	Yes.
1	Monroe	Dundee	D. E. Martin	....do	July 30	25	8.2	71.7	Yes.
2	....do	....do	C. V. Paul	Strandes' Zehringen	....do	5	8.6	.....	Yes.
3	....do	....do	....do	Vilmorin's Improved	....do	7	8	75.7	Yes.
4	....do	....do	H. C. Schultz	Kleinwanzlebener (Dippe)	....do	4	9.4	.....	Yes.
5	....do	....do	....do	Strandes' Zehringen	....do	5	8.6	.....	Yes.
6	....do	....do	....do	Vilmorin's Improved	....do	4	9.5	.....	Yes.
7	....do	....do	G. W. Toburen	Kleinwanzlebener (Dippe)	....do	8	10.8	77	Yes.
8	....do	....do	....do	Strandes' Zehringen	....do	6	11.5	.....	Yes.
9	....do	....do	J. Boldt	Vilmorin's Improved	....do	8	9	72	Yes.
10	....do	....do	....do	Kleinwanzlebener (Dippe)	....do	9	9.2	71.3	
11	....do	....do	H. P. Morse	....do	....do	6	8.3	.....	Yes.
12	....do	....do	I. Lloyd	....do	....do	10	7.4	65.7	Yes.
13	....do	....do	J. F. Koepke	Strandes' Zehringen	July 28	13	7.5	62.7	Yes.

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Serial number.	State or Territory and county.	Post-office.	Experimenter.	Variety.	When harvested.	Average weight.	Sugar in the beet.	Purity coefficient.	Was season favorable?
	MICHIGAN—continued.					*Ounces.*	*Per cent.*		
14	Monroe □	Dundee	C. Happy	Vilmorin's Improved	July 30	10	9	69.9	Yes.
15	do	do	do	Kleinwanzlebener (Dippe)	do	14	9.1	72.2	Yes.
16	do	do	H. Jasper	do	do	8	8.7	76.3	
17	do	do	do	Vilmorin's Improved	do	8	7.5	65.4	Yes.
18	do	do	do	Vilmorin's French Very Rich	do	14	7.8	65.6	Yes.
19	do	do	do	Kleinwanzlebener (Dippe)	do	6	11.5	.....	Yes.
20	do	do	do	Vilmorin's Improved	do	6	10.9	.....	Yes.
21	do	do	E. Kent	do	do	8	10.7	76.4	Yes.
22	do	do	do	Vilmorin's French Very Rich	July 31	13	9.8	71.5	Yes.
23	do	do	do	Kleinwanzlebener (Dippe)	do	9	10	74.1	
24	do	do	N. Jasper	do	Aug. 21	13	11.9	80.2	Yes.
25	do	do	E. Kent	do	do	8	12.7	79.8	Yes.
26	do	do	T. Brandt	do	do	8	10.4	75.7	Yes.
27	do	do	M. H. Kellogg	Vilmorin's Improved	do	8	10.6	82.3	Yes.
28	do	do	T. Brandt	do	do	8	9.4	78.3	Yes.
29	do	do	C. V. Paul	do	do	5	8.6	75.2	
30	do	do	T. Brandt	do	do	6	8.8	73.2	Yes.
31	do	do	do	Kleinwanzlebener (Dippe)	do	11	9.4	71.7	Yes.
32	do	do	do	do	do	8	9.4	71.2	Yes.
33	do	do	W. F. Lafler	do	do	11	8.9	72.9	Yes.
34	do	do	F. Hall	Vilmorin's Improved	do	18	9.2	74	Yes.
35	do	do	E. Kent	Vilmorin's French Very Rich	do	12	8.4	70.4	Yes.
36	do	do	C. V. Paul	Strandes' Zehringen	do	9	8.3	60.8	Yes.
37	do	do	T. Brandt	Vilmorin's Improved	do	9	9	77.9	Yes.
38	do	do	do	Kleinwanzlebener (Dippe)	do	6	10.1	75.7	Yes.
39	do	do	do	do	do	12	9.8	75.2	Yes.
40	do	do	do	Vilmorin's Improved	do	10	9	76	No.
41	do	do	H. M. Smith	Kleinwanzlebener (Dippe)	do	10	10.5	75.9	Yes.
42	do	do	T. Brandt	do	do	7	8.6	70.3	Yes.
43	do	do	Chas. Happy	do	do	12	10.5	75.9	Yes.
44	do	do	H. Jasper	Vilmorin's French Very Rich	do	11	9	71.6	Yes.
45	do	do	W. J. Kelley	Vilmorin's Improved	do	14	8.3	72	Yes.
46	do	do	W. F. Crowe	Kleinwanzlebener (Dippe)	do	8	11.5	76.1	Yes.
47	do	do	H. Jasper	Vilmorin's French Very Rich	do	10	11.2	74.2	Yes.
48	do	do	T. Brandt	Kleinwanzlebener (Dippe)	do	5	10.2	74.3	Yes.
49	do	do	do	Schreiber's Elite	Aug. 24	8	8.9	73.4	Yes.
50	do	do	W. F. Crowe	Kleinwanzlebener (Dippe)	Aug. 21	6	9.6	73.7	No.
51	do	do	H. Jasper	Vilmorin's Improved	do	9	9.5	74.1	No.

52	....do	....do	T. Brandt	Knauer's Mangold	....do	13	8.1	62.9	Yes.
53	....do	....do	....do	Vilmorin's French Very Rich	....do	5	8.2	67.7	Yes.
54	....do	....do	H. Jasper	Vilmorin's Improved	....do	13	12.1	77.5	Yes.
55	....do	....do	T. Brandt	Kleinwanzlebener (Dippe)	....do	10	10.6	75	Yes.
56	....do	....do	....do	....do	....do	6	9	74.8	Yes.
57	....do	....do	H. Jasper	....do	....do	8	10	74.5	Yes.
58	....do	....do	W. F. Crowe	....do	....do	9	10.9	76.7	Yes.
59	....do	....do	H. Jasper	....do	....do	15	10	77.8	Yes.
60	....do	....do	H. C. Rodd	Vilmorin's Improved	....do	15	10.5	75.9	Yes.
61	....do	....do	N. J. Carney	Vilmorin's French Very Rich	....do	11	8.2	70.5	No.
62	....do	....do	H. Jasper	Kleinwanzlebener (Dippe)	....do	10	11.3	78.3	Yes.
63	....do	....do	....do	Vilmorin's Improved	....do	13	9.5	74.6	Yes.
64	....do	....do	N. J. Carney	Kleinwanzlebener (Dippe)	....do	16	9.1	72.2	Yes.
65	....do	....do	....do	Vilmorin's French Very Rich	....do	20	10.6	75.5	Yes.
66	....do	....do	H. Jasper	Vilmorin's Improved	....do	17	9.9	74.8	Yes.
67	....do	....do	J. Boldt	Kleinwanzlebener (Dippe)	....do	16	10	77.8	Yes.
68	....do	....do	I. Lloyd	....do	....do	8	9	71.4	Yes.
69	....do	....do	W. F. Crowe	....do	....do	17	10.6	76.2	Yes.
71	....do	....do	E. C. Post		Aug. 10	15	10.4	74.2	
72	....do	....do	....do		Aug. 27	11	12.7	81.2	
73	....do	....do	Wm. Jasper	Kleinwanzlebener (Dippe)	Aug. 21	18	9.9	74.3	Yes.
94	....do	....do	D. T. Hall	Vilmorin's Improved	....do	16	9.1	70.1	Yes.
95	....do	....do	E. C. Post		....do	14	8	66.1	Yes.
96	....do	....do	N. L. Sage	Kleinwanzlebener (Dippe)	....do	13	9.1	71.1	Yes.
97	....do	....do	W. F. Brandt	Vilmorin's French Very Rich	....do	7	9.7	70.8	Yes.
98	....do	....do	W. E. Knabush	Vilmorin's Improved	....do	12	8.7	72.4	Yes.
99	....do	....do	J. F. Koptie	Strandes' Zehringen	....do	17	10.8	73.5	Yes.
100	....do	....do	D. Scranton	Kleinwanzlebener (Dippe)	....do	7	8	62.2	Yes.
101	....do	....do	C. Valuet	....do	....do	9	10.7	75.3	Yes.
102	....do	....do	A. Haysted	Vilmorin's Improved	....do	8	7.6	67.2	Yes.
103	....do	....do	F. W. Wittkop	Kleinwanzlebener (Dippe)	....do	8	10.7	75.3	Yes.
104	....do	....do	E. C. Post		....do	11	8.7	73.6	Yes.
105	....do	....do	F. R. Smith	Kleinwanzlebener (Dippe)	....do	6	9.4	73.9	Yes.
106	....do	....do	F. C. Banner	Strandes' Zehringen	....do	7	9.4	71.2	Yes.
107	....do	....do	Wm. Johnson	Kleinwanzlebener (Dippe)	....do	9	9.1	73.3	Yes.
108	....do	....do	J. Boldt	Vilmorin's Improved	....do	6	9.7	73.9	Yes.
109	....do	....do	D. T. Hall	....do	....do	10	9.8	72	Yes.
110	....do	....do	C. Happy	....do	....do	11	11.2	80.3	Yes.
111	....do	....do	E. C. Post	Kleinwanzlebener (Dippe)	....do	4	10.1	88.3	Yes.
112	....do	....do	J. Boldt	....do	....do	8	10.5	76.9	Yes.
113	....do	....do	N. L. Sage	Vilmorin's Improved	....do	9	9.1	69.6	Yes.
114	....do	....do	C. Valuet	Vilmorin's French Very Rich	....do	9	10.5	75.3	Yes.
115	....do	....do	C. Wittkop	Kleinwanzlebener (Dippe)	....do	7	9.9	74.8	Yes.
116	....do	....do	F. Haysted	Strandes' Zehringen	....do	12	10.6	76	Yes.
117	....do	....do	G. W. Toburen		....do	12	10.8	80.3	Yes.
118	....do	....do	F. Meus	Strandes' Zehringen	....do	8	9.8	75.8	Yes.
119	....do	....do	A. H. Schultz	....do	....do	7	9.7	71.3	Yes.
120	....do	....do	E. Austen	....do	Aug. 27	15	11.2	79.7	Yes.
121	....do	....do	....do	Kleinwanzlebener (Dippe)	....do	17	9.4	75	Yes.
122	....do	....do	E. C. Post	Vilmorin's Improved	Aug. 31	9	10.6	81.2	Yes.
147	....do	....do	G. W. Miller	Kleinwanzlebener (Dippe)	Sept. 7	17	10.8	71.3	Yes.
149	....do	....do	E. Kent	Vilmorin's Improved	Sept. 11	15	12.4	78.3	Yes.

Results of analyses of sugar beets in the chemical laboratory of the Department of Agriculture during the year 1900, by States—Continued.

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Serial number.	State or Territory and county.	Post-office.	Experimenter.	Variety.	When harvested.	Average weight.	Sugar in the beet.	Purity coefficient.	Was season favorable?
	MICHIGAN—continued.					*Ounces.*	*Per cent.*		
150	Monroe□	Dundee	A. M. Collis	Kleinwanzlebener (Dippe)	Sept. 11	15	12.2	76.6	Yes.
151	do	do	E. Kent	Vilmorin's Improved	do	17	11.8	76.5	Yes.
152	do	do	Wm. Johnson	Kleinwanzlebener (Dippe)	do	22	12	75.9	Yes.
153	do	do	H. Jasper	Vilmorin's French Very Rich	do	8	13.3	79.1	Yes.
154	do	do	H. Vogelsong	Kleinwanzlebener (Dippe)	do	13	10	75	Yes.
155	do	do	F. W. Wittkop	do	do	7	11.9	81.2	Yes.
156	do	do	H. Jasper	Vilmorin's Improved	do	13	14.1	80.9	Yes.
158	do	do	do	do	do	8	10.1	70.2	Yes.
204	do	do	B. E. Bullock	Kleinwanzlebener (Dippe)	do	11	11.7	80.4	Yes.
206	do	do	D. A. Pelton	Vilmorin's Improved	do	9	10.5	75.9	Yes.
208	do	do	E. C. Post	do	do	10	9.9	74.8	Yes.
209	do	do	B. E. Bullock	Kleinwanzlebener (Dippe)	do	10	9.6	72.7	Yes.
210	do	do	N. J. Cornig	Vilmorin's French Very Rich	do	10	10.5	72.8	Yes.
211	do	do	F. C. Bamm	Strandes' Zehringen	do	12	11.6	79.7	Yes.
215	do	do	J. F. Koppe	do	do	16	12.5	77.6	Yes.
216	do	do	E. Auten	do	do	16	12.5	81	Yes.
217	do	do	Wm. Johnson	Kleinwanzlebener (Dippe)	do	13	11.8	78.5	Yes.
218	do	do	H. Vogelsong	do	do	9	11.9	78.2	Yes.
219	do	do	W. F. Crowe	do	do	8	12.6	77.3	Yes.
220	do	do	F. Winkleman	do	do	7	10.1	75.7	Yes.
221	do	do	W. F. Crowe	do	do	10	12.1	77.9	Yes.
222	do	do	do	Kleinwanzlebener	do	11	12.7	78.4	Yes.
223	do	do	F. Haysted	Strandes' Zehringen	do	21	12.5	78	Yes.
224	do	do	J. Boldt	Kleinwanzlebener (Dippe)	do	11	9.2	76.4	Yes.
225	do	do	B. C. Drew	do	do	13	8.1	67	Yes.
226	do	do	C. Happy	do	do	12	12.5	78	Yes.
227	do	do	T. D. Volker	Strandes' Zehringen	do	20	10	73.4	Yes.
228	do	do	H. Jasper	Kleinwanzlebener (Dippe)	do	13	9.8	71	Yes.
229	do	do	H. Vogelsong	do	Sept. 10	9	11.1	72.7	Yes.
230	do	do	G. W. Toburen	Strandes' Zehringen	Sept. 11	20	11.4	78.4	Yes.
231	do	do	N. L. Sage	Vilmorin's Improved	do	18	10.6	74.2	Yes.
232	do	do	C. V. Paul	Strandes' Zehringen	do	19	10.3	78.3	Yes.
233	do	do	W. F. Crowe	Kleinwanzlebener (Dippe)	do	11	11.7	78.4	Yes.
234	do	do	J. Boldt	Vilmorin's Improved	do	7	9	73.1	Yes.
235	do	do	G. W. Toburen	Kleinwanzlebener (Dippe)	do	19	11.8	78.5	Yes.
236	do	do	W. J. Kelley	do	do	16	10.6	79.4	Yes.
238	do	do	C. Happy	Vilmorin's Improved	do	17	13.4	85.5	Yes.
239	do	do	H. P. Seem	Strandes' Zehringen	do	6	13.3	80.1	Yes.

240	do	do	do	do	do	7	13	82.5	Yes.
172	do	do	B. E. Bullock	Vilmorin's Improved	do	10	11.8	78.5	Yes.
173	do	do	do	do	do	8	10.3	72	Yes.
174	do	do	H. C. Rodd	Kleinwanzlebener (Dippe)	do	13	10.3	73.3	Yes.
175	do	do	B. E. Bullock	do	do	10	11.7	75.5	Yes.
176	do	do	C. F. Barker	Strandes' Zehringen	do	8	11.3	75.4	
177	do	do	B. E. Bullock	Vilmorin's Improved	do	8	11.3	76.3	Yes.
178	do	do	A. Shaw	Kleinwanzlebener (Dippe)	do	8	11.8	76.5	Yes.
179	do	do	B. E. Bullock	Schrieber's Elite	do	11	11.8	76.1	Yes.
180	do	do	do	Kleinwanzlebener (Dippe)	do	14	11.3	72.6	Yes.
181	do	do	E. C. Post	Vilmorin's Improved	do	10	11.9	74.9	
182	do	do	H. C. Schultz	do	do	11	11.7	77.4	Yes.
183	do	do	F. L. Lafler	Kleinwanzlebener (Dippe)	do	17	12.1	77.5	Yes.
184	do	do	Wm. Johnson	Vilmorin's Improved	do	13	12	77.3	Yes.
185	do	do	H. P. Morse	Kleinwanzlebener (Dippe)	do	14	11	75.8	Yes.
186	do	do	H. C. Rodd	Vilmorin's Improved	do	13	11.8	26.1	Yes.
187	do	do	B. E. Bullock	Kleinwanzlebener	do	20	11.6	77.7	Yes.
188	do	do	N. J. Corney	do	do	18	11.8	76.5	Yes.
190	do	do	B. E. Bullock	Vilmorin's Improved	do	6	11.2	76.6	Yes.
191	do	do	W. J. Kelley	do	do	14	9.5	70.4	Yes.
192	do	do	E. S. Haight	Kleinwanzlebener (Dippe)	do	9	8.4	62.9	Yes.
193	do	do	B. E. Bullock	do	do	13	10.9	75.2	Yes.
194	do	do	F. Lieb	do	do	10	9.7	72.3	Yes.
195	do	do	N. J. Corney	Vilmorin's Improved	do	18	13	80.1	Yes.
196	do	do	B. E. Bullock	Kleinwanzlebener (Dippe)	do	12	12.5	78.1	Yes.
197	do	do	do	Knauer's Mangold	do	12	12	77.3	Yes.
198	do	do	N. C. Schultz	Strandes' Zehringen	do	9	11.4	78.4	Yes.
199	do	do	B. E. Bullock	Kleinwanzlebener (Dippe)	do	9	10.2	72.8	Yes.
200	do	do	do	Kleinwanzlebener	do	11	12.5	75.8	Yes.
201	do	do	H. C. Schultz	Kleinwanzlebener (Dippe)	do	15	10.8	76.5	Yes.
202	do	do	H. Jasper	Vilmorin's Improved	do	14	14.5	78.5	Yes.
203	do	do	do	do	do	14	11.3	77.8	Yes.
90	do	do	I. Lloyd	Kleinwanzlebener (Dippe)	Aug. 21	18	7.7	64.3	Yes.
91	do	do	Wm. Johnson	do	do	8	9	69.8	Yes.
92	do	do	H. Wittkop	Strandes' Zehringen	do	11	8.7	71.3	Yes.
93	do	do	D. T. Hall	Kleinwanzlebener (Dippe)	do	11	10.2	74.8	Yes.
647	do	do	E. C. Post	Kleinwanzlebener	Oct. 22	7	14.5	.....	Yes.
638	do	do	B. E. Bullock	do	Oct. 23	19	10.5	75.3	Yes.
641	do	do	do	do	do	13	13.3	82.8	Yes.
643	do	do	do	do	do	15	14	81.2	Yes.
654	do	do	do	do	do	8	12	78.8	Yes.
660	do	do	do	Schreiber's Elite	do	13	12.1	77.5	Yes.
661	do	do	do	Kleinwanzlebener (Dippe)	do	12	12.5	79	Yes.
663	do	do	do	Vilmorin's French Very Rich	do	10	10.9	76.7	Yes.
664	do	do	do	do	do	11	10.9	76.2	Yes.
665	do	do	do	Kleinwanzlebener	do	11	14.3	83.3	Yes.
667	do	do	do	Vilmorin's Improved	do	9	13.3	82.3	Yes.
668	do	do	do	Kleinwanzlebener	do	11	13.8	82.8	Yes.
669	do	do	do	do	do	16	14	81.7	Yes.
672	do	do	do	Knauer's Mangold	do	14	11.5	77	Yes.
673	do	do	do	Kleinwanzlebener	do	16	13.2	80.8	Yes.
698	do	do	do	Vilmorin's Improved	do	9	12.2	81.5	Yes.

Results of analyses of sugar beets in the chemical laboratory of the Department of Agriculture during the year 1900, by States—Continued.

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Serial number.	State or Territory and county.	Post-office.	Experimenter.	Variety.	When harvested.	Average weight.	Sugar in the beet.	Purity coefficient.	Was season favorable?
	MICHIGAN—continued.					*Ounces.*	*Per cent.*		
690	Monroe □	Dundee	B. E. Bullock	Vilmorin's Improved	Oct. 23	13	12.6	81.1	Yes.
725	do	Raisinville	C. Happy	Kleinwanzlebener	do	11	13.7	86.2	Yes.
726	do	do	do	Vilmorin's Improved	do	13	11.8	82.1	Yes.
746	do	Dundee	F. Haysted	Strandes' Zehringen	do	18	13.9	81.6	Yes.
759	do	do	A. Haysted	Vilmorin's Improved	do	9	10.9	77.2	Yes.
758	do	do	J. F. Koppa	Strandes' Zehringen	do	17	14.8	83.9	Yes.
763	do	do	F. C. Bamm	do	do	12	11.9	80.2	Yes.
760	do	do	J. Boldt	Vilmorin's Improved	do	4	10.3	.....	Yes.
160	do	do	E. Kent	Kleinwanzlebener (Dippe)	Sept. 11	14	13.9	82.9	Yes.
161	do	do	A. H. Schultz	Strandes' Zehringen	do	9	13.4	81.5	Yes.
162	do	do	Wm. E. Knabush	Vilmorin's Improved	do	26	10.5	79.1	
163	do	do	H. Jasper	do	do	12	12	74.1	Yes.
164	do	do	H. P. Seem	Strandes' Zehringen	do	4	13.7	82.3	Yes.
165	do	do	H. Jasper	Vilmorin's Improved	do	14	13.9	81.1	Yes.
166	do	do	C. V. Paul	do	do	16	10.6	77.2	Yes.
167	do	do	E. C. Post	Strandes' Zehringen	do	22	11.2	75.2	Yes.
168	do	do	R. Willard	Vilmorin's Improved	do	13	6.6	62.7	Yes.
169	do	do	H. Jasper	Kleinwanzlebener (Dippe)	do	8	13.3	78.2	Yes.
171	do	do	P. J. Tingley	Vilmorin's Improved	do	10	11.4	75.5	Yes.
241	do	do	E. Auten	Kleinwanzlebener (Dippe)	do	15	13.2	79.9	Yes.
242	do	do	E. C. Post	do	do	14	10.2	74.3	Yes.
243	do	do	T. Hall	Vilmorin's Improved	do	16	11.8	78	Yes.
244	do	do	C. Valuet	Vilmorin's French Very Rich	do	25	12.1	80.8	Yes.
245	do	do	do	Kleinwanzlebener (Dippe)	do	24	11.9	77.1	Yes.
246	do	do	do	do	do	19	12.5	78.6	Yes.
250	do	do	F. Meus	Strandes' Zehringen	do	9	13.6	83.1	Yes.
251	do	do	E. Teachout	Kleinwanzlebener (Dippe)	do	17	11.7	78.8	Yes.
252	do	do	D. E. Martin	Vilmorin's Improved	do	16	11.1	77.9	Yes.
253	do	do	H. Jasper	Kleinwanzlebener (Dippe)	do	9	17.7	86.1	Yes.
254	do	do	N. Allison	do	do	6	12.5	81.4	Yes.
255	do	do	E. C. Post		Sept. 17	12	11.9	77.2	
271	do	do	G. S. Wakefield	Vilmorin's Improved	do	41	10.3	77.1	Yes.
282	do	do	E. C. Post	Licht's Zuckerreichste	Sept. 18	6	12.5	.....	Yes.
283	do	do	do	do	do	4	15.5	.....	Yes.
284	do	do	do	do	do	9	18.1	84.1	Yes.
285	do	do	do	do	do	10	16.5	83.2	Yes.
286	do	do	do	do	do	8	15.7	80.1	Yes.
889	do	do	H. P. Morse	Kleinwanzlebener (Dippe)	Oct. 2	11	12.1	79.8	Yes.

388	do	do	H. Jasper	do	do	13	12.1	76		
387	do	do	do	do	do	16	12.1	77.5	Yes.	
386	do	do	B. E. Bullock	do	do	13	12.2	80	Yes.	
385	do	do	do	do	do	12	11.4	76.4	Yes.	
384	do	do	do	do	do					
383	do	do	do	Vilmorin's Improved	do	12	12.3	79.2	Yes.	
382	do	do	G. N. Miller	Kleinwanzlebener (Mrozinski)	do	14	12.1	79.9	Yes.	
380	do	do	B. E. Bullock	Kleinwanzlebener (Dippe)	do	15	13.4	81.5	Yes.	
379	do	do	J. Boldt	Vilmorin's Improved	do	5	10.6	77.8	Yes.	
390	do	do	Van De Venter & Sons	Knauer's Mangold	do	31	8.2	62.7	Yes.	
397	do	do	A. Shaw	Kleinwanzlebener (Dippe)	do	8	15.2	85.1	Yes.	
396	do	do	William Johnson	do	do	14	13.9	80.7	Yes.	
395	do	do	E. C. Post	do	do	9	11.2	76.1	Yes.	
394	do	do	T. Volker	Strandes' Zehringen	do	11	14.5	79.7	Yes.	
393	do	do	do	do	do	19	9.9	66.7	Yes.	
399	do	do	E. C. Post	Vilmorin's French Very Rich	do	14	10.5	71.9	Yes.	
400	do	do	S. P. Smith	Kleinwanzlebener (Dippe)	do	14	12.1	78.4	Yes.	
401	do	do	A. H. Schultz	Strandes' Zehringen	do	12	14.4	85.8	Yes.	
403	do	do	A. C. Schultz	Kleinwanzlebener	do	11	13.3	80.9	Yes.	
402	do	do	C. Greenfield	Strandes' Zehringen	do	30	13	80.6	Yes.	
404	do	do	B. C. Drew	Kleinwanzlebener	do	11	9.1	72.2	Yes.	
405	do	do	F. W. Wittkop	do	do	10	12.9	81.4	Yes.	
407	do	do	B. E. Bullock	Vilmorin's Improved	do	11	10.7	71.1	Yes.	
408	do	Ida	H. P. Seem	Strandes' Zehringen	do	11	12.5	83.5	Yes.	
409	do	Dundee	J. S. Koepka	do	do	23	13.6	87.2	Yes.	
411	do	Ida	H. P. Seem	do	do	7	12.5	83.4	Yes.	
420	do	do	do	do	do	6	12.5	81.5	Yes.	
415	do	Dundee	I. Lloyd	Kleinwanzlebener	do	12	9.8	73	Yes.	
417	do	do	W. Crowe	do	do	8	12.5	84.1	Yes.	
443	do	do	E. Kent	Vilmorin's Improved	do	12	12.5	79	Yes.	
430	do	do	do	Kleinwanzlebener	do	13	13.8	78.8	Yes.	
426	do	do	do	Vilmorin's French Very Rich	do	14	14	85	Yes.	
464	do	do	B. E. Bullock	do	do	13	11.7	76	Yes.	
463	do	do	do	Kleinwanzlebener	do	7	11.4	76.9	Yes.	
460	do	do	do	Vilmorin's French Very Rich	do	10	11.9	78.2	Yes.	
458	do	do	do	Schreiber's Elite	do	9	11.4	75.5	Yes.	
456	do	do	do	Kleinwanzlebener	do	8	11	74.8	Yes.	
447	do	do	do	do	do	18	10.8	77	Yes.	
466	do	do	do	Knauer's Mangold	do	13	11.4	77.4	Yes.	
124	do	do	do	Kleinwanzlebener	do	13	12.5	78.6	Yes.	
431	do	do	do	do	do	11	13.8	81.5	Yes.	
453	do	do	do	Vilmorin's Improved	do	16	11	74.4	Yes.	
198	do	do	H. C. Rodd	Kleinwanzlebener	do	11	12.8	77.2	Yes.	
499	do	do	W. F. Layler	do	do	12	13.5	82.1	Yes.	
440	do	do	C. M. Glasgow	Strandes' Zehringen	do	9	11.6	77.2	Yes.	
457	do	do	N. J. Corney	Kleinwanzlebener	do	15	12.9	81.9	Yes.	
446	do	do	do	Vilmorin's French Very Rich	do	18	11.8	78.5	Yes.	
421	do	do	F. Meus	Strandes' Zehringen	do	13	12.8	79	Yes.	
450	do	do	J. Boldt	Kleinwanzlebener	do	11	8.8	71.6	Yes.	
422	do	do	N. C. Schultz	Vilmorin's Improved	do	9	13	82	Yes.	
437	do	do	H. C. Schultz	Strandes' Zehringen	do	8	13	82	Yes.	
448	do	do	A. M. Glasgow	Kleinwanzlebener	do	13	10.5	77.5	Yes.	

Results of analyses of sugar beets in the chemical laboratory of the Department of Agriculture during the year 1900, by States—Continued.

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Serial number.	State or Territory and county.	Post-office.	Experimenter.	Variety.	When harvested.	Average weight.	Sugar in the beet.	Purity coefficient.	Was season favorable?
	MICHIGAN—continued.					*Ounces.*	*Per cent.*		
451	Monroe □	Dundee	T. Hall	Vilmorin's Improved	Oct. 2	15	12	75	Yes.
496	....do	....do	G. W. Toburen	Kleinwanzlebener	....do	12	12.7	81.7	Yes.
'94	....do	....do	C. V. Paul	Vilmorin's Improved	....do	9	10.4	74.6	Yes.
495	....do	....do	E. C. Post	Kleinwanzlebener	....do	14	9.4	71.2	Yes.
490	....do	....do	M. H. Kellogg		....do	17	10.9	78.8	Yes.
485	....do	....do	C. Schroder	Kleinwanzlebener	Oct. 3	12	12.1	76	Yes.
482	....do	....do	H. C. Rodd	Vilmorin's Improved	Oct. 2	9	11.8	76.1	Yes.
467	....do	....do	D. E. Martin	....do	....do	26	9.2	68.8	Yes.
465	....do	....do	H. Jasper	....do	....do	12	13.1	78	Yes.
462	....do	....do	F. Lieb	Kleinwanzlebener	....do	8	8.9	80.3	Yes.
455	....do	....do	D. T. Hall	Vilmorin's Improved	Oct. 3	31	10.4	73.2	Yes.
436	....do	....do	N. L. Sage	Kleinwanzlebener	Oct. 2	15	11.4	75	Yes.
459	....do	....do	W. F. Crowe	....do	....do	9	10.2	75.9	Yes.
445	....do	....do	....do	....do	....do	11	12.8	79.9	Yes.
468	....do	....do	....do	....do	....do	9	12.5	78.6	Yes.
476	....do	....do	A. M. Smith	....do	Oct. 3	15	11.4	77.4	Yes.
470	....do	Raisinville	C. Happy	Vilmorin's Improved	Oct. 2	15	12.2	77.6	Yes.
469	....do	....do	....do	Kleinwanzlebener	....do	13	13.6	83.1	Yes.
481	....do	....do	C. L. Rehburg	Strandes' Zehringen	....do	28	9.7	69.4	Yes.
501	....do	Dundee	C. V. Paul	....do	Oct. 5	9	10.2	77.5	Yes.
506	....do	....do	G. W. Toburen	....do	Oct. 2	19	11.6	78.2	Yes.
650	....do	Raisinville	E. Teachout	Kleinwanzlebener (Dippe)	Oct. 22	27	7.9	52.5	Yes.
682	....do	London	N. Allison	....do	Oct. 23	6	11.7	80.9	Yes.
699	....do	Dundee	D. E. Martin	Vilmorin's Improved	....do	16	11	74.8	Yes.
649	....do	....do	E. Teachout	Kleinwanzlebener	....do	23	11.7	78.4	Yes.
692	....do	....do	F. Lieb	....do	....do	9	10	78.4	Yes.
761	....do	....do	J. Boldt	....do	....do	6	8.8	75	Yes.
763	....do	....do	C. Wittkop	....do	....do	5	11.4	80.5	Yes.
765	....do	....do	....do	....do	....do	5	18.5	85	Yes.
754	....do	....do	W. F. Crowe	....do	....do	7	12.2	82.1	Yes.
756	....do	....do	....do	....do	....do	8	11.1	79.6	Yes.
764	....do	....do	....do	....do	....do	7	11.9	80.7	Yes.
767	....do	....do	....do	....do	....do	6	12.3	83.2	Yes.
752	....do	Exeter	W. C. Richards	....do	....do	15	12.4	78.3	Yes.
74	....do	....do	C. Voluet	Vilmorin's Improved	Aug. 21	15	10.5	76.9	Yes.
75	....do	....do	D. E. Martin	....do	....do	15	10.6	76.5	Yes.
76	....do	....do	N. J. Corney	Kleinwanzlebener (Dippe)	....do	5	8	67.9	Yes.
77	....do	....do	E. C. Post	....do	....do	7	10.4	79.2	Yes.

78	do	do	J. Hilton	Vilmorin's Improved	do	40	6.6	68	Yes.
79	do	do	E. C. Post		Aug. 27	15	9.2	70.8	Yes.
80	do	do	E. Teachout	Kleinwanzlebener (Dippe)	Aug. 21	12	8.5	71.7	
81	do	do	D. Scranton	Vilmorin's Improved	do	7	8	68.3	Yes.
82	do	do	E. C. Post	Kleinwanzlebener (Dippe)	do	12	6.6	65.7	Yes
83	do	do	H. P. Morse	do	Aug. 20	8	9.1	74.4	Yes.
84	do	do	H. Vogelsang	do	Aug. 21	6	7.6	67.2	Yes.
85	do	do	Van De Venter & Son	Knauer's Mangold	do	9	7.9	66.9	
86	do	do	H. P. Seem	Strandes' Zehringen	do	10	8.8	78.1	Yes.
87	do	do	G. W. Toburen	Kleinwanzlebener (Dippe)	do	11	10.3	76.6	Yes.
88	do	do	H. C. Rodd	do	do	15	9.8	72.5	Yes.
89	do	do	A. Shaw	do	do	8	10.6	78.3	Yes.
689	do	do	T. Hall		Oct. 23	11	14	82.1	Yes.
640	do	do	H. C. Schultz	Vilmorin's Improved	do	12	12.9	82.9	Yes.
675	do	do	do	Kleinwanzlebener	do	13	12.5	82.9	Yes.
688	do	do	do	Strandes' Zehringen	do	7	12.8	84.9	Yes.
666	do	do	E. Kent	Vilmorin's French Very Rich	do	11	14.7	83.8	Yes.
686	do	do	do	Kleinwanzlebener	do	9	14.9	83.1	Yes.
679	do	do	N. J. Corney	Vilmorin's French Very Rich	do	20	11.7	80.9	Yes.
674	do	do	C. V. Paul	Strandes' Zehringen	do	6	13.2	81.8	Yes.
655	do	do	do	Vilmorin's Improved	do	10	11.1	72.2	Yes.
656	do	do	H. P. Morse	Kleinwanzlebener	do	8	12.2	81.5	Yes.
644	do	do	Van De Venter & Son	Knauer's Mangold	do	16	11.6	78.7	Yes.
636	do	do	H. C. Rodd	Kleinwanzlebener	do	16	12.5	80.5	Yes.
635	do	do	E. Auten	Strandes' Zehringen	do	13	15.8	87.4	Yes
633	do	do	H. C. Rodd	Vilmorin's Improved	do	18	10.8	76	Yes.
632	do	do	E. Kent	do	do	9	14.1	84.1	Yes.
631	do	do	G. W. Miller	Kleinwanzlebener	do	13	10	77.8	Yes.
634	do	do	E. C. Post	do	Oct. 22	6	15.9		Yes.
637	do	do	do	do	do	12	15.2		Yes.
642	do	do	do	do	do	12	18.8		Yes.
709	do	Raisinville	W. J. Kelley	Vilmorin's Improved	Oct. 23	13	10.8	77.6	Yes.
707	do	Dundee	G. W. Toburen	Kleinwanzlebener	do	13	11.1	79.1	Yes.
706	do	do	C. F. Barker	Strandes' Zehringen	do	18	11.1	80.7	Yes.
705	do	do	T. D. Volker	do	do	15	12.8	80.9	Yes.
704	do	do	N. J. Corney	Vilmorin's French Very Rich	do	20	10.9	77.2	Yes.
703	do	do	J. Hand	Vilmorin's Improved	do	19	9.8	75.2	Yes.
702	do	do	N. J. Corney	Kleinwanzlebener	do	13	15.7	84.2	Yes.
712	do	do	T. D. Volker	Strandes' Zehringen	do	15	10.3	74	Yes.
713	do	do	G. W. Toburen	do	do	21	10.3	74	Yes.
715	do	do	I. Lloyd	Kleinwanzlebener	do	8	10.3	78.3	Yes.
718	do	do	W. J. Kelley	do	do	11	12.1	80.9	Yes.
899	do	do	E. C. Post	do	Nov. 15	13	15.1		Yes.
898	do	do	do	do	do	10	15.5		Yes.
897	do	do	do	do	do	6	14		Yes.
896	do	do	do	do	do	12	15		Yes.
895	do	do	do	do	do	14	12.1		Yes.
839	do	do	N. J. Corney	Vilmorin's French Very Rich	Nov. 6	64	10.6	77.1	Yes.
900	do	Monroe	G. S. Wakefield	Vilmorin's Improved	Nov. 13	30	11.8	76.5	Yes.
926	do	do	E. Kent	do	Nov. 20	10	12.7	82.7	Yes.
928	do	do	B. E. Bullock	Vilmorin's French Very Rich	do	7	13.9	85.9	Yes.
930	do	do	E. Kent	Kleinwanzlebener	do	7	15.7	90.7	Yes.

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Serial number.	State or Territory and county.	Post-office.	Experimenter.	Variety.	When harvested.	Average weight.	Sugar in the beet.	Purity coefficient.	Was season favorable?
	MICHIGAN—continued.					*Ounces.*	*Per cent.*		
922	Monroe □	Monroe	B. E. Bullock	Vilmorin's Improved	Nov. 20	9	14.4	85.8	Yes.
606	Montcalm □	Edmore	C. W. Curtis	do	Oct. 19	15	11.5	78.5	Yes.
812	do	do	do	do	Nov. 2	18	12.7	81.7	Yes.
936	do	Butternut	E. W. Johnson	do	Nov. 19	33	10.1	73.1	Yes.
814	Oakland □	Davisburg	A. L. Gregory	do	Nov. 1	37	10	75.6	Yes.
304	St. Clair □	Marine City	C. O. Smith	Kleinwanzlebener (Dippe)	Sept. 20	73	9.8		Yes.
577	do	Peters	V. E. Boehmer		Oct. 13	26	13.3	78.7	Yes.
576	do	do	do		Oct. 15	63	10.9	69.2	Yes.
883	do	Brockway	Wm. Mason	Kleinwanzlebener	Nov. 19	18	14.6	81.9	Yes.
595	St. Joseph □	Mendon	C. Mumby		Oct. 20	26	12.6	78.7	Yes.
517	do	do	S. H. Alvord	Kleinwanzlebener	Oct. 5	12	12.4	82.8	Yes.
519	do	do	do	Strandes' Zehringen	do	13	10.8	79.7	Yes.
514	do	do	do	Vilmorin's Improved	do	12	8.4	72.1	Yes.
544	do	do	do	Kleinwanzlebener	do	8	11.1	78	Yes.
729	do	do	J. Mumby		Oct. 20	24	15	83.6	Yes.
143	Tuscola □	Ellington	N. Emmons	Vilmorin's Improved	Sept. 5	20	9.6	76.5	Yes.
310	do	Caro	E. Reynolds	do	Sept. 20	15	11.7	76	Yes.
472	do	do	S. F. Mercer	do	Oct. 6	16	12.6	75.6	Yes.
604	do	do	J. Williams	Kleinwanzlebener	Oct. 19	61	10	74.5	Yes.
691	do	Ellington	C. Wickware	do	Oct. 21	15	13	80.1	Yes.
791	do	Caro	E. Reynolds	Vilmorin's Improved	Oct. 29	25	13.4	82.9	Yes.
905	do	do	J. G. Meiller	Kleinwanzlebener	Nov. 13	24	14.4	86.4	Yes.
280	Van Buren □	Bangor	M. W. Hyenga	Vilmorin's Improved	Sept. 17	37	8.9	74.6	Yes.
279	do	do	do	Kleinwanzlebener (Dippe)	do	26	11.3	79.4	Yes.
159	Washtenaw □	Pittsfield	J. Hentzman	Strandes' Zehringen	Sept. 11	82	9.1	75.6	Yes.
365	do	do	do	do	Oct. 2	32	10.2	71.3	
410	do	Milan	P. J. Tingbey	Vilmorin's Improved	do	17	11.9	78.1	Yes.
412	do	do	Wm. Johnson	do	do	17	12.2	75.7	Yes.
419	do	do	E. Auten	Strandes' Zehringen	do	18	12	74.6	Yes.
478	do	do	A. M Collis	Vilmorin's Improved	do	18	11.7	74.6	Yes.
461	do	do	Wm. Johnson	Kleinwanzlebener	do	13	12.2	81.5	Yes.
452	do	do	H. Jasper	Vilmorin's Improved	do	9	10.7	74.9	Yes.
449	do	do	do	Kleinwanzlebener	do	12	11	75.8	Yes.
444	do	do	do	Vilmorin's Improved	do	18	11.3	78.8	Yes.
442	do	do	do	Kleinwanzlebener	do	10	13.8	79.7	Yes.
441	do	do	do		do	12	11.1	80.7	Yes.
439	do	do	do	Vilmorin's Improved	do	18	12.1	79.8	Yes.
438	do	do	E. E. Spink	Kleinwanzlebener	Oct. 8	1	9		Yes.

434	.....do	.....do	S. P. Smith	.....do	Oct. 2	6	10.7	72.9	Yes.
427	.....do	.....do	E. Auten	.....do	.....do	14	13.2	81.8	Yes.
423	.....do	.....do	N. Allison	.....do	.....do	5	10.6	78.7	Yes.
695	.....do	.....do	H. Jasper	.....do	Oct. 23	12	13.5	84	Yes.
687	.....do	.....do	.....do	Vilmorin's Improved	.....do	12	12.6	83.6	Yes.
671	.....do	.....do	.....do	Vilmorin's French Very Rich	.....do	12	12	81.3	Yes.
694	.....do	.....do	E. Auten	Kleinwanzlebener	.....do	7	13.7	84.2	Yes.
670	.....do	.....do	H. Jasper	.....do	.....do	12	11.4	80	Yes.
662	.....do	.....do	.....do	Vilmorin's Improved	.....do	13	12.1	81.4	Yes.
659	.....do	.....do	.....do	Kleinwanzlebener	.....do	14	12.2	82.1	Yes.
658	.....do	.....do	.....do	.....do	.....do	15	12.3	79.2	Yes.
657	.....do	.....do	.....do	Vilmorin's Improved	.....do	13	12.5	79	Yes.
646	.....do	.....do	.....do	Vilmorin's French Very Rich	.....do	12	13.1	83.1	Yes.
639	.....do	.....do	.....do	Kleinwanzlebener	.....do	21	12.6	79.7	Yes.
734	.....do	.....do	C. Valuet	.....do	.....do	18	12.1	82.5	Yes.
745	.....do	.....do	.....do	Vilmorin's French Very Rich	.....do	13	12.2	78	Yes.
753	.....do	.....do	.....do	Vilmorin's Improved	.....do	17	13.2	81.8	Yes.
755	.....do	.....do	Wm. Johnson	Kleinwanzlebener	.....do	23	12.2	80.5	Yes.
766	.....do	.....do	.....do	.....do	.....do	17	12.7	80.7	Yes.
743	.....do	.....do	.....do	Vilmorin's Improved	.....do	20	14.3	84.3	Yes.
711	.....do	.....do	A. Shaw	Kleinwanzlebener	.....do	14	11.9	78.2	Yes.
925	.....do	.....do	H. Jasper	Vilmorin's French Very Rich	Nov. 20	12	10.1	74.1	Yes.
927	.....do	.....do	.....do	Vilmorin's Improved	.....do	15	13.5	86.6	Yes.
923	.....do	.....do	.....do	.....do	.....do	10	11.3	76.8	Yes.
931	.....do	.....do	.....do	Kleinwanzlebener	.....do	11	12.5	79.1	Yes.
932	.....do	.....do	.....do	.....do	.....do	9	14.4	86.9	Yes.
381	.....do	.....do	.....do	Vilmorin's French Very Rich	Oct. 2	12	12.1	77.9	Yes.
237	Wayne □	Brownstown Township.	H. M. Smith	Kleinwanzlebener (Dippe)	Sept. 11	13	14	83	Yes.
678	.....do	.....do	.....do		Oct. 23	18	13.8	82.8	Yes.
821	.....do	Rawsonville	A. L. Yeckley	Kleinwanzlebener	Nov. 2	70	10.6	76.2	Yes.
	State averages (478 samples).					14	11.3	76.7	
	MINNESOTA.								
142	Becker □	Osage	E. D. Sylvester	Strandes' Zehringen	Sept. 4	37	10.6	77.2	No.
263	Carver □	Victoria	G. Van Sloan	Kleinwanzlebener (Dippe)	Sept. 13	13	11.8	83.2	No.
265	.....do	.....do	.....do		Sept. 12	16	12.7	85.9	No.
376	.....do	.....do	J. Ruppel		Sept. 30	33	11.6	76.7	No.
268	Clay □	Hawley	W. Fountain		Sept. 13	11	9.8	75.8	No.
888	Jackson □	Lakefield	H. W. Wehl		Nov. 12	34	13.4	76.7	Yes.
721	Pope □	Lowry	J. Hrdlicka	Kleinwanzlebener (Mrozinski)	Oct. 24	48	9.4	67.8	No.
491	Renville □	Renville	K. Warner	Kleinwanzlebener	Oct. 3	53	9.6	73.2	No.
502	.....do	.....do	.....do	.....do	.....do	32	8.5	63.1	No.
558	Stearns □	St. Cloud	F. Mesenburg	.....do	Oct. 25	32	11.7	79.4	No.
	State averages (10 samples).					31	10.9	75.9	

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Serial number.	State or Territory and county.	Post-office.	Experimenter.	Variety.	When harvested.	Average weight.	Sugar in the beet.	Purity coefficient.	Was season favorable?
	MISSOURI.					*Ounces.*	*Per cent*		
128	Audrain □	Mexico	B. F. Shepherd	Vilmorin's Improved	Sept. 4	12	10.4	72.7	Yes.
256	Cass -□	Strasburg	F. Long		Sept. 15	11	9	63.7	No.
264	Jefferson □-	Desoto	J. F. G. Herget	Vilmorin's Improved	Sept. 13	15	9.6	77.7	No.
258	.....do	.....do	.....do	.....do	.....do	16	8.4	68.2	No.
332	.....do	Pevely	F. Thomi	Kleinwanzlebener (Dippe)	Sept. 22	9	10.2	78.8	
968	Shelby ◸	Shelbina	J. S. Chandler		Nov. 14	6	6.6	57	No.
495	St. Louis City □-	St. Louis	R. L. Coleman	Kleinwanzlebener and Vilmorin.	Oct. 4	23	9.7	71.3	Yes.
500	Wayne ◺	Zeitonia	O. C. Lucy	Kleinwanzlebener	.....do	26	7	64.3	Yes.
503	.....do	.....do	.....do	.....do	.....do	17	5.4	56.4	Yes.
	State averages (9 samples).					15	8.5	67.2	
	MONTANA.								
278	Choteau ⌂	Chinook	H. J. Badger	Vilmorin's Improved	Sept. 15	17	10.6	71.6	No.
338	Fergus □	Elso	H. Willis	Kleinwanzlebener (Dippe)	Sept. 20	57	10.8	75.5	No.
601	Flathead ◹	Kalispell	C. A. Lynch		Oct. 15	33	13.1	71.9	No.
492	Madison ◿	Pageville	H. Utley		Oct. 2	44	6.9	60.3	Yes.
	State averages (4 samples).					38	10.4	69.8	
	NEBRASKA.								
587	Butler □-	Edholm	F. F. Loomis	Kleinwanzlebener	Oct. 17	25	11.8	76.5	No.
521	Douglas □-	Omaha	Omaha Loan and Trust	.....do	Oct. 11	26	11.8	80.5	Yes.
570	.....do	.....do	A. Williams	.....do	Oct. 15	35	9	69.9	Yes.
569	.....do	.....do	W. R. Aituran	.....do	.....do	36	8.4	67.2	Yes.
610	.....do	.....do	P. O'Dwyer	.....do	Oct. 20	33	8.1	62.9	No.
784	.....do	.....do	Omaha Loan and Trust	.....do	Oct. 31	34	11.2	78.7	Yes.
299	Dundy □	Ives	A. R. Thomas	Kleinwanzlebener (Dippe)	Sept. 17	35	7.5	66.4	No.
813	Gosper ⍁	Elwood	J. H. Tockheck		Sept. 21	11	11.5	74.3	No.
815	.....do	Bertrand	W. W. Lewis	Vilmorin's Improved	Sept. 19	15	10.2	70.4	No.
821	Johnson ◺	Tecumseh	W. A. Clineburg		Nov. 7	24	10	72.9	Yes.
294	Valley □	Ord	W. A. Anderson	Kleinwanzlebener (Dippe)	Sept. 18	30	9.6	73.7	Yes.
	State averages (11 samples).					28	9.9	72.1	

	NEVADA.								
966	Washoe □	Reno	Experiment Station	Vilmorin's Improved	Nov. 17	9	8.6	84.9	Yes.
960	do	do	do	Strandes' Zehringen	do	10	10.1	75.2	Yes.
961	do	do	do	Kleinwanzlebener	do	11	10.2	78.7	Yes.
	State averages (3 samples).					10	9.6	79.6	
	NEW HAMPSHIRE.								
579	Cheshire □	Nelson	T. W. Barker	Vilmorin's Improved	Oct. 16	26	11.1	75.9	Yes.
822	do	do	do	do	Nov. 1	33	12.6	80.1	Yes.
621	Merrimack □	Pittsfield	J. W. Sanborn		Oct. 24	24	9.5	71.9	No.
622	do	do	do		Oct. 17	27	10.2	73.3	No.
627	do	do	do		Oct. 24	23	12.6	77.4	Yes.
623	do	do	J. E. Leighton		Oct. 16	45	10	72.4	No.
624	do	do	W. H. White		do	23	11	73.4	No.
625	do	do	J. C. McIntosh		do	40	12.2	76.2	No.
626	do	do	Wm. E. Smith	Vilmorin's Improved	Oct. 17	16	11	73.9	No.
	State averages (9 samples).					29	11.1	74.9	
	NEW JERSEY.								
890	Cumberland □	Rosenhayn	J. A. Williams	Kleinwanzlebener	Nov. 12	20	8.8	69.9	No.
903	Monmouth □	Matawan	C. M. White	Vilmorin's Improved	Nov. 14	21	14	83.5	Yes.
	State averages (2 samples).					21	11.4	76.7	
	NEW MEXICO.								
826	San Juan □	Jewett	E. Marceline	Vilmorin's Improved	Nov. 1	21	14.1	75.5	Yes.
833	do	do	do	do	do	25	14.8	80	Yes.
	Averages (2 samples)					23	14.5	77.8	
	NEW YORK.								
935	Cattaraugus □	Great Valley	H. M. Beeles	Kleinwanzlebener (Mrozinski)	Nov. 19	9	13.8	84.3	No.
934	do	do	do	Kleinwanzlebener	do	21	13.	80.6	
944	do	do	do	Kleinwanzlebener (Mrozinski)	do	21	13	80.6	No.
943	do	do	do	Strandes' Zehringen	do	11	14.1		
942	do	do	do	Vilmorin's Improved	do	17	13.2	78.1	No.
475	Chautauqua □	Ellington	E. N. Kelly	do	Oct. 4	11	11.4	77.4	No.
547	do	Hamlet	Wm. E. Judd		Oct. 10	13	13.6	80.3	Yes.
789	do	Brocton	H. W. Pettit	Vilmorin's Improved	Oct. 30	14	14.4	83.1	No.
829	do	Dunkirk	F. Werle	Kleinwanzlebener	Nov. 3	21	14.6	82.8	No.

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Serial number.	State or Territory and county.	Post-office.	Experimenter.	Variety.	When harvested.	Average weight.	Sugar in the beet.	Purity coefficient.	Was season favorable?
	NEW YORK—continued.					*Ounces.*	*Per cent.*		
985	Chautauqua □	Silvercreek	S. Morse	Kleinwanzlebener (Mrozinski No. 2).	Dec. 5	21	13.1	83.6	No.
986	....do	....do	W. H. Jacobs	Kleinwanzlebener	Dec. 6	38	13	83.5	No.
906	Genesee -□	Oakfield	B. W. Taylor	....do	Nov. 13	14	15	83.6	Yes.
374	Jefferson □̄	Theresa	E. H. Cooper		Oct. 1	11	11	77.3	
617	....do	Natural Bridge	M. A. Samson		Oct. 22	31	12.6	77.8	No.
615	....do	....do	I. Arnold		....do	19	12.3	82.7	No.
730	....do	Watertown	G. L. Gardner	Vilmorin's Improved	Oct. 24	20	13.7	87.8	No.
719	....do	....do	P. O'Brien	....do	....do	18	13.5	84.5	No.
844	....do	Alexandria Bay	J. F. Parker	Kleinwanzlebener	Nov. 5	34	11.9	76.3	No.
840	....do	....do	A. H. Houghton		Nov. 8	32	11.6	78.7	No.
852	....do	....do	R. Deans	New Danish	Nov. 7	29	9.7	70.3	No.
887	....do	Threemile Bay	A. D. Fawre		Nov. 12	9	8.3	70.2	No.
909	....do	Ellisburg	D. C. Woodruff	Vilmorin's Improved	Nov. 14	16	11.6	77.2	No.
613	Livingston -□	Dansville	A. Carey	....do	Oct. 22	14	11.9	76.3	No.
894	Niagara -□	Lockport	E. Kamper		Nov. 13	53	10.5	75.9	No.
904	....do	....do	....do		....do	51	11.7	75.5	No.
531	Ontario -□	Naples	F. Greiner	Kleinwanzlebener	Oct. 9	12	13.9	81.1	No.
972	....do	Geneva	New York Experiment Station.	Vilmorin's Improved	Dec. 10	18	14.4	80.3	
973	....do	....do	....do	White Queen of the North	....do	18	14.9	81.8	
976	....do	....do	....do	....do	....do	17	15.1	80.7	
982	....do	....do	....do	....do	....do	16	17.2	86.1	
979	....do	....do	....do	....do	....do	16	17.3	85.4	
977	....do	....do	....do	Kleinwanzlebener (Austrian Special).	....do	17	15.2	83.8	
980	....do	....do	....do	....do	....do	17	15.6	82.8	
983	....do	....do	....do	....do	....do	16	15.3	84.3	
984	....do	....do	....do	....do	....do	15	16.5	82.1	
974	....do	....do	....do	....do	....do	17	14.4	82.2	
978	....do	....do	....do	Vilmorin's Improved	....do	19	16.2	83.7	
981	....do	....do	....do	....do	....do	16	15.8	83.8	
975	....do	....do	....do	....do	....do	19	14	80.3	
855	Oswego □	Fulton	W. S. Nelson	....do	Nov. 5	17	13.1	72.2	No.
750	St. Lawrence □̄	Tilden	Wm. Camal		Oct. 27	28	10.1	74.1	No.
901	Seneca □	Waterloo	N. L. Utzman	Vilmorin's Improved	Nov. 14	27	11	72.6	No.
497	Steuben □	South Canisteo	A. Wilson		Oct. 5	35	10	78.2	Yes.
678	....do	Adrian	F. E. Hush	Vilmorin's Improved	Oct. 10	17	13.1	77.3	Yes.

614	Suffolk	Port Jefferson	H. W. Miller	Kleinwanzlebener	Oct. 23	33	11.4	78.2	Yes.
583	Wayne	Macedon Center	Mrs. M. E. Pulver	do	Oct. 22	7	15.5		No.
825	do	Lyons	H. G. Hotchkins	do	Oct. 20	28	12.6	78.7	No.
834	do	do	do	Vilmorin's Improved	Nov. 5	28	11.3	78.8	Yes.
303	Wyoming	Perry	Wm. Wickings	do	do	27	14.7	87.1	Yes.
302	do	do	do	do	Sept. 22	52	10.6	75	No.
					do	32	11.8	77.5	No.
	State averages (51 samples).					22	13.3	79.8	
	NORTH CAROLINA.								
618	Alleghany	Edwards Crossroads	H. M. Crouse	Kleinwanzlebener	Oct. 20	31	11.3	76.8	No.
820	do	do	do	do	Nov. 1	13	10.7	74.4	No.
226	Montgomery	Troy	W. A. Foreman	Kleinwanzlebener (Dippe)	Sept. 14	28	7.5	74	No.
723	Watauga	Virgil	F. N. Hardin	Kleinwanzlebener	Oct. 24	20	11.5	80.2	No.
	State averages (4 samples).					23	10.3	76.4	
	NORTH DAKOTA.								
607	Bottineau	Willow City	J. M. Lazier	Kleinwanzlebener	Oct. 16	11	12	78.3	No.
522	Dickey	Monango	C. G. Fait		Oct. 11	44	7.1	66.3	
308	Grand Forks	Larimore	J. Lunney		Sept. 20	17	8.9	68.6	Yes.
291	McHenry	Velva	W. A. McKern	Kleinwanzlebener (Dippe)	Sept. 18	19	10.6	73.5	No.
859	Rolette	St. John	F. A. Bourcassa	Kleinwanzlebener	Nov. 5	20	12.4	73.8	No.
	State averages (5 samples).					22	10.2	71.1	
	OHIO.								
272	Athens	Albany	H. Fisher	Russian	Sept. 20	27	7.6	67.2	No.
868	Carroll	Sherodsville	M. M. Belknap	Kleinwanzlebener	Nov. 8	63	9.3	69.5	No.
807	Clark	Enon	D. Baker	Vilmorin's Improved	Nov. 1	11	10.5	71.4	Yes.
808	Crawford	Galion	J. H. Cook	Kleinwanzlebener	Nov. 3	22	9.3	69	No.
992	Cuyahoga	Nottingham	F. A. Bowman		Dec. 15	32	14.1	85.1	
860	Franklin	Grove City	S. Taylor	Kleinwanzlebener	Nov. 12	14	9.5	69.4	No.
858	do	do	do	Vilmorin's Improved	do	13	11.5	77	No.
965	Henry	Deshler	J. C. Waltimere	Kleinwanzlebener	Nov. 10	17	11.6	79.7	Yes.
951	Huron	Norwalk	J. E. Hafner	do	Nov. 21	17	12.4	77.4	No.
529	Knox	Mount Vernon	R. J. Ash	do	Oct. 11	51	8.1	63.4	Yes.
540	do	do	do	do	do	64	6.3	64	Yes.
886	do	Howard	A. Blue		Nov. 11	12	11.9	80.2	No.
504	do	Lock	Dr. J. W. Haines	Kleinwanzlebener	Oct. 6	11	8.4	70.4	No.
946	Lake	Little Mountain	A. M. Carver		Nov. 20	19	10.6	72.3	No.
548	Marion	Marion	S. Bolander	Kleinwanzlebener	Oct. 10	27	7.6	64	No.
367	Mercer	Coldwater	T. Tecamp	Kleinwanzlebener (Dippe)	Oct. 1	25	8.1	64.8	Yes.
343	do	St. Peter	B. Grieshop	Vilmorin's Improved	Sept. 29	19	9.2	67.8	No.
342	do	Coldwater	H. Saalman	Kleinwanzlebener (Dippe)	Sept. 27	26	12.5	75.8	Yes.

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Serial number.	State or Territory and county.	Post-office.	Experimenter.	Variety.	When harvested.	Average weight.	Sugar in the beet.	Purity coefficient.	Was season favorable?
	OHIO—continued.					*Ounces.*	*Per cent.*		
337	Mercer □	Coldwater	Mrs. B. Isverding		Sept. 27	16	13.5	78.9	Yes.
596	.....do	Macedon	N. Denny		Oct. 23	18	9.9	71.7	Yes.
542	.....do	Coldwater	B. Gerdes	Switzberger	Oct. 13	42	10.2	72.3	Yes.
676	.....do	Philothea	H. Steggemann	Kleinwanzlebener	Oct. 22	21	12.5	84	Yes.
677	.....do	Macedon	William Curry		.....do	28	7.5	68	Yes.
684	.....do	Coldwater	H. Hageman	Kleinwanzlebener	Nov. 18	18	10.7	.....	Yes.
727	.....do	.....do	C. Stuckenborg	Vilmorin's Improved	Oct. 24	23	9.8	72	Yes.
793	.....do	Montezuma	H. B. Bennett		Oct. 29	11	11.1	70.9	Yes.
799	.....do	Philothea	G. H. Duer		Nov. 1	26	12.6	76.9	Yes.
802	.....do	Carthagena	H. Dahlingher		Oct. 30	36	9.9	72.2	Yes.
884	.....do	Coldwater	H. Vogel	Vilmorin's Improved	Nov. 12	14	12.2	74	Yes.
530	Montgomery □	Dayton	R. P. Dickey, jr		Oct. 10	30	7.6	60.6	No.
731	.....do	.....do	J. Boughnecht	Kleinwanzlebener	Oct. 24	24	8.8	72.6	Yes.
333	Muskingum □	Fultonham	D. H. Coleman	Vilmorin's Improved	Sept. 24	12	9.9	72.7	No.
794	Ottawa □	Oak Harbor	C. Vallin	.....do	Oct. 30	37	11.5	72.4	No.
739	.....do	.....do	L. Seelig	.....do	Oct. 27	16	11.8	75.2	Yes.
375	Paulding □	Melrose	H. Harrell	.....do	Oct. 1	14	10.6	73.2	No.
369	.....do	Oakwood	A. R. Sattler		.....do	30	9.8	75.7	Yes.
335	.....do	Paulding	S. Brattam	Kleinwanzlebener	Sept. 25	25	9.7	73.9	No.
599	.....do	Mondale	J. L. Anderson	Kleinwanzlebener (Dippe)	Oct. 20	23	10	75	Yes.
738	.....do	.....do	J. B. Renner	.....do	Oct. 26	39	9.4	69.7	Yes.
963	.....do	Payne	J. Bique		Nov. 24	43	8.9	68.6	No.
267	Putnam □	Leipsic	J. Siefker		Sept. 15	23	11.2	78.1	
370	.....do	Ottorville	Wm. Schlagbaum	Vilmorin's Improved	Sept. 28	34	9.2	65.9	Yes.
539	.....do	Leipsic	C. W. Falk		Oct. 12	27	8.6	69.8	Yes.
645	.....do	Fort Jennings	F. W. Helmkamp	Kleinwanzlebener	Oct. 22	35	11.6	84.7	No.
735	.....do	Glandorf	H. Recker	.....do	Oct. 21	19	8.4	67.2	Yes.
736	.....do	.....do	.....do	.....do	Oct. 26	14	9.5	69.4	Yes.
768	.....do	Leipsic	G. A. Fike	.....do	Oct. 27	23	12.1	77	Yes.
774	.....do	Hector	A. J. Troyer	.....do	Oct. 29	20	11	79.4	Yes.
273	Richland □	Davis	J. W. McConkie	Vilmorin's Improved	Sept. 17	18	8.9	72.3	No.
796	Sandusky □	Fremont	J. Rimelspach	Kleinwanzlebener	Nov. 1	27	13.6	81.3	Yes.
832	.....do	.....do	G. P. Hafford		Nov. 5	15	14.7	83.8	Yes.
827	.....do	.....do	A. H. Speller	Kleinwanzlebener	.....do	22	11.4	77.4	No.
882	.....do	.....do	C. H. Depp	.....do	Nov. 9	26	12.5	81.5	Yes.
949	.....do	.....do	J. Rimelspach	.....do	Nov. 24	11	11.9	76.7	Yes.
605	Summit □	Ira	C. O. Hale		Oct. 19	25	7.7	68.8	No.
797	Union □	Watkins	O. Kirby		Oct. 29	20	9.9	71.7	No.
805	Warren □	Franklin	D. S. Parker	Kleinwanzlebener	Nov. 9	40	9.1	71.1	Yes.

772	....do	Wooster	Prof. C. E. Thorn		Oct. 29	14	14.3	84	
329	Wood	Dunbridge	F. Rogers	Vilmorin's Improved	Sept. 24	54	7.2	63.8	Yes.
373	....do	Sugar Ridge	F. Tietjen	....do	Oct. 1	38	8.8	69.4	Yes.
507	....do	....do	J. D. Smith		Oct. 8	28	11.4	76.9	Yes.
795	....do	....do	....do	Kleinwanzlebener	Nov. 29	22	12.6	77.4	Yes.
877	....do	Custer	D. N. Howe		Nov. 10	33	10.5	72.4	No.
	State averages (64 samples).					26	10.3	73.1	
	OKLAHOMA.								
316	Custer	Butler	J. N. Klein		Sept. 12	25	11.6	70.1	
290	Kingfisher	Kingfisher	J. W. Best	Kleinwanzlebener (Dippe)	Sept. 18	29	10.5	69.1	No.
292	....do	....do	....do	....do	....do	24	10.7	70.2	No.
749	Lincoln	Carney	Miss E. S. Arnold		Oct. 24	9	9.4	.....	No.
	Averages (4 samples)					22	10.6	69.8	
	OREGON.								
776	Harney	Lawen	A. F. B. George	Vilmorin's Improved	Oct. 20	33	11.2	73.3	Yes.
488	Josephine	Williams	A. C. Shinn	Vilmorin's Improved	Sept. 27	27	10.6	78.3	No.
603	....do	....do	....do	....do	Oct. 13	26	10	74.5	No.
347	Linn	Crawfordsville	O. P. Goodall		Sept. 24	12	12.3	83.2	No.
597	....do	....do	....do		Oct. 15	20	11.6	79.2	No.
528	Umatilla	Weston	R. B. Fream	Kleinwanzlebener	Oct. 7	19	17	87.3	Yes.
189	Union	Richland	F. Craig		Sept. 8	8	12.1	77	Yes.
212	....do	....do	....do		....do	11	10.5	75.9	Yes.
295	....do	La Grande	W. L. Owsley	Kleinwanzlebener (Dippe)	Sept. 17	8	15.7	86	Yes.
398	....do	Telocaset	E. Conlon	Vilmorin's Improved	Oct. 1	31	13.2	78.1	No.
307	Wallowa	Joseph	F. X. Musty	....do	Sept. 19	18	11.7	75	No.
	State averages (11 samples).					19	12.4	78.9	
	PENNSYLVANIA.								
361	Chester	Loag	P. W. Nagle		Oct. 3	23	9.5	73.5	
798	Clarion	Kingsville	D. O. Ken		Oct. 24	18	12.7	75.7	Yes.
918	....do	....do	....do		Nov. 12	14	13.7	85.2	No.
917	Cumberland	Carlisle	F. C. Bosler	Kleinwanzlebener	Nov. 19	13	10	74	No.
913	....do	....do	....do	....do	....do	12	9.2	68.3	No.
788	Erie	Erie	D. Schlosser	Vilmorin's Improved	Nov. 1	18	13.2	82.2	No.
867	....do	....do	....do	....do	....do	26	9.7	74.5	No.
778	Montgomery	Colmar	Mrs. N. Dates	....do	Oct. 30	26	9.8	73.6	Yes.
924	....do	Oaks	T. Highley		Nov. 21	29	11.2	79.2	Yes.
891	Philadelphia	Frankford	W. K. Browu	Vilmorin's Improved	Nov. 12	31	10.7	74.4	Yes.
371	York	Windsor	D. A. Heindel		Oct. 1	23	6.7	62.3	No.
	State averages (11 samples).					21	10.6	74.8	

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Serial number.	State or Territory and county.	Post-office.	Experimenter.	Variety.	When harvested.	Average weight.	Sugar in the beet.	Purity coefficient.	Was season favorable?
	SOUTH CAROLINA.					*Ounces.*	*Per cent.*		
260	Chester □̄	Chester	A. Owens		Sept. 17	21	7.7	84.8	No.
213	Chesterfield □̄	Catarrh	Wm. Middleton		Sept. 5	22	9.7	72.9	No.
146	Lancaster □̄	Van Wyck	J. M. Swett		do	44	7.8	70.7	No.
	State averages (3 samples).					29	8.4	69.5	
	SOUTH DAKOTA.								
512	Clay □̲	Vermilion	J. T. Olson		Oct. 8	25	9.6	72.7	Yes.
588	Deuel □̄	Clear Lake	A. J. Lockhart		Oct. 15	20	11.8	74.3	Yes.
842	Jerauld □	Parsons	L. G. Wilson	Kleinwanzlebener	Nov. 5	12	13.1	78	Yes.
680	Lincoln □̲	Worthing	E. W. Norton	Desprez	Oct. 20	11	8.1	69	No.
413	Lyman □̲	Earling	Mrs. M. L. Armstrong	Kleinwanzlebener	Sept. 29	9	13.5	73.9	Yes.
314	Sanborn □	Forestburg	J. Salisbury		Sept. 25	13	12.1	77.5	Yes.
493	do	do	do		Oct. 2	27	8.2	64.1	Yes.
584	Spink □	Redfield	C. A. Anderson		Oct. 17	87	9.2	69.8	No.
586	do	do	do		do	58	8.8	65.9	No.
	State averages (9 samples).					29	10.5	71.7	
	TENNESSEE.								
298	Bedford □	Wartrace	W. S. Waite	Kleinwanzlebener (Dippe)	Sept. 18	15	5.4	54.8	No.
	State average (1 sample).					15	5.4	54.8	
	TEXAS.								
132	Comal □	New Braunfels	J. Laux	Kleinwanzlebener (Dippe)	Aug. 29	26	3.8	33	Yes.
131	do	do	do	do	do	38	3.8	38.8	Yes.
301	do	Anhalt	A. Doeppenschmidt		Sept. 4	7	10.9	72.8	
317	do	New Braunfels	H. E. Pentsh	Kleinwanzlebener (Dippe)	Sept. 16	13	6.2	57.9	No.
322	do	Anhalt	G. Letsch	do	Sept. 21	32	9.5	82	No.
330	do	do	do	do	do	17	9.8	71.5	No.
331	do	Crane's Mill	R. Fustel	do	Sept. 27	7	8.7	60.9	Yes.
564	do	Solms	Wm. Hubertus		Oct. 2	60	8	81.7	Yes.

875	Eastland ▫	Jewett	T. Hixon		Nov. 8	43	2	29.1	Yes.
555	Jack ▫	Bryson	W. F. Bottom		Oct. 15	11	4.6	46.6	No.
737	do	do	do		Oct. 23	35	5.2	38.5	No.
559	Llano □	Llano	S. P. Collier	Vilmorin's Improved	Oct. 9	44	7.6	61.1	Yes.
748	do	do	do		Oct. 25	27	9 1	66.6	Yes.
355	Taylor ▫	Guion	M. L. Holt		Sept. 24	45	7.1	62.5	No.
813	do	do	do		Oct. 31	47	7.8	67.2	No.
	State averages (15 samples).					29	6.9	56.8	
	UTAH.								
861	Utah □	Payson	J. Amos		Nov. 1	11	12.9		No.
841	do	do	do		do	16	15	83.2	No.
567	Wasatch □	Heber	J. Crook	Kleinwanzlebener	Oct. 18	13	16.7	83.1	Yes.
779	do	do	do	do	Oct. 24	15	15.6	84.5	No.
261	Weber ▫	Harrisville	D. Crowther	Kleinwanzlebener (Dippe)	Sept. 23	15	8.6	74.4	Yes.
	State averages (5 samples).					14	13.8	81.3	
	VERMONT.								
477	Bennington ▫	Rupert	B. Harwood	Vilmorin's Improved	Oct. 3	9	11.4	78.4	Yes.
720	Orleans ▫	Gloverton	W. F. Clark		Oct. 22	16	11.6	78.7	No.
863	Rutland ▫	N. Clarendon	G. A. Squin		Nov. 6	19	13.3	81.9	No.
	State averages (3 samples).					15	12.1	79.7	
	VIRGINIA.								
516	Albemarle □	Charlottesville	W. C. Chamberlain	Kleinwanzlebener	Nov. 6	4	7.9		No.
806	do	do	do		Oct. 16	3	9.7	70.3	No.
845	Amelia □	Dutch	Wm. Haver	Vilmorin's Improved	Nov. 8	39	10.6	70.9	No.
489	Caroline □	Delos	J. B. Hicks		Oct. 9	17	7.3	73.3	No.
568	do	Sparta	G. L. Haynes		Oct. 15	22	11.3	79.4	No.
562	do	do	do		do	18	10	71.9	No.
563	do	Bowling Green	J. L. Jordan		Oct. 16	15	8.8	68.9	No.
685	do	do	W. H. Gravatt		Oct. 23	4	13	79.7	No.
954	do	do	W. B. Covington	Kleinwanzlebener	Nov. 20	14	10.4	70.8	No.
952	do	Lent	S. B. Hearn		Nov. 28	25	10.3	74	No.
866	Culpeper ▫	Jeffersonton	T. Heflin	Imperial	Nov. 5	31	11.8	76.5	No.
696	Fauquier ▫	Midland	G. W. Armstrong	Kleinwanzlebener	Oct. 23	26	10	76.7	No.
681	do	do	do	do	do	16	9.9	74.8	No.
947	Henrico □	Richmond	J. G. Fitzgerald		Nov. 24	31	8.8	68.9	No.
921	Lancaster □	Irvington	Mrs. A. I. Mussick	Vilmorin's Improved	Nov. 17	41	8.2	70.5	No.
911	do	do	do	Kleinwanzlebener	Nov. 16	28	7.8	44.3	No.
518	Orange □	Lahore	T. S. Casey	do	Oct. 9	15	10.6	78.3	Yes.
873	do	Unionville	R. Waugh	Kleinwanzlebener (Mrozinski)	Nov. 10	35	9.8	75.7	Yes.
809	do	do	W. C. Newman	do	Nov. 3	14	10.3	73.5	No.
835	do	do	Mrs. C. Stewart	do	do	28	7.1	61.5	No.

Results of analyses of sugar beets in the chemical laboratory of the Department of Agriculture during the year 1900, by States—Continued.

[The symbol following name of county indicates the location of the county within the State, as follows: □, central; ⊓, northern; ⊐, eastern; ⊔, southern; ⊏, western; ⊓, northwestern; ⊐, northeastern; ⊔, southeastern; ⊔, southwestern.]

Serial number.	State or Territory and county.	Post-office.	Experimenter.	Variety.	When harvested.	Average weight.	Sugar in the beet.	Purity coefficient.	Was season favorable?
	VIRGINIA—continued.					*Ounces.*	*Per cent.*		
473	Prince William ⊓	Manassas	G. W. Johnson		Oct. 5	18	9.5	75.2	No.
358	Spottsylvania □	Fredericksburg	S. B. Richardson		Oct. 1	9	8.9	73.4	No.
366	do	do	A. A. Canaday	Kleinwanzlebener (Dippe)	Oct. 3	8	10.1	75.7	No.
505	do	do	J. T. Coleman	do	Oct. 6	17	7.6	69.6	No.
785	do	do	do		Oct. 26	9	10.2	72.8	No.
744	do	do	A. Silver	Vilmorin's Improved	Oct. 27	9	9.7	73.4	No.
869	do	Leavells	W. T. Kennedy	Kleinwanzlebener	Nov. 3	14	10.5	71.4	No.
916	do	Fredericksburg	A. Silver		Nov. 17	12	10.5	74	No.
938	do	Leavells	W. F. Stephens		Nov. 10	11	10.5	74	No.
969	do	do	J. B. Jerrell	Kleinwanzlebener	Nov. 30	11	10.5	74.3	No.
564	do	Fredericksburg	J. H. Smith	do	Oct. 16	13	9.5	71.4	No.
572	do	do	J. A. Sullivan	Strandes' Zehringen	Oct. 15	12	10.4	78.4	No.
777	do	do	S. Granger	do	Oct. 30	14	9.7	74.5	No.
803	do	do	J. H. Brown	do	Nov. 2	8	7.2	67.3	No.
919	do	do	S. Granger	do	Nov. 16	11	10.3	74	No.
990	do	do	J. A. Sullivan	Kleinwanzlebener (Mrozinski)	Dec. 12	6	12.4	85	No.
989	do	do	do	do	do	29	12	80.8	No.
991	do	do	do	do	do	14	12.3	83.8	No.
549	Stafford ⊓	Leeland	J. E. Berry	do	Oct. 12	11	8.6	73.8	No.
509	do	Falmouth	C. J. Chartiers	Kleinwanzlebener	Oct. 9	17	8.6	79.1	No.
560	do	Leeland	O. Berry		Oct. 12	20	7.9	68	Yes.
537	do	Berea	Wm. Clark	Kleinwanzlebener	Oct. 11	10	11.4	82.8	No.
857	do	Leeland	J. E. Bowler	do	Nov. 8	15	12.2	77.1	No.
880	do	Stafford	G. W. Truslow	Strandes' Zehringen	Nov. 7	31	9	75.4	No.
920	do	Falmouth	C. J. Chartiers	Kleinwanzlebener	Nov. 19	18	11.8	78.5	No.
948	do	do	B. W. Irwin	do	Nov. 23	16	11.7	76.4	No.
987	do	Leeland	W. H. Gallahan	do	Nov. 27	14	11.5	79.1	No.
988	do	do	S. Graninger	Strandes' Zehringen	Dec. 12	72	11.1	79.1	No.
885	Wythe ⊔	Max Meadows	G. C. Black		Nov. 2	10	11.7	77.4	No.
	State averages (49 samples).					18	10	74.1	
	WASHINGTON.								
368	Thurston ⊏	Tenino	Mrs. S. A. Van Tine	Strandes' Zehringen	Sept. 29	22	15.2	87	No.
846	Yakima ⊔	Ahtanum	D. B. Greenwater	Kleinwanzlebener (Mrozinski)	Nov. 2	26	14.6	84.2	Yes.
	State averages (2 samples).					24	14.9	86.6	

	WEST VIRGINIA.								
520	Raleigh	Egeria	A. J. Hatcher	Kleinwanzlebener	Oct. 6	5	10.2	.....	No.
690	....do	....do	....do	....do	Oct. 20	7	13	.....	No.
811	Wayne	Round Bottom	J. Prichard		....do...	13	7.5	62.7	Yes.
805	Wirt	Lee	A. E. Black	Kleinwanzlebener (Dippe)	Oct. 18	4	12	.....	No.
	State averages (4 samples).					7	10.7	62.7	
	WISCONSIN.								
326	Adams	Oxford	A. H. Flook	Kleinwanzlebener (Dippe)	Sept. 24	30	8.6	67.4	No.
350	....do	Spring Creek	R. H. Gleason	Vilmorin's Improved	Sept. 25	17	10.6	74.7	No.
300	Columbia	Kilbourn	M. M. Hayes		Sept. 20	34	9.1	70.1	No.
594	....do	....do	....do		Oct. 19	49	9.7	67.6	No.
800	Crawford	Retreat	A. A. James		....do...	32	9.1	67.6	No.
127	Dane	Madison	F. W. Woll	Vilmorin's Improved	Sept. 1	12	11.7	81.5	Yes.
124	....do	....do	....do	White Queen of the North	....do...	13	12	81.8	Yes.
125	....do	....do	....do	Kleinwanzlebener (Austrian Special).	....do...	12	12.2	83.7	Yes.
870	Dunn	Connersville	D. J. Pickard	Kleinwanzlebener	Nov. 6	73	11.4	76.4	No.
769	Grant	Platterville	M. L. Moses	Vilmorin's Improved	Oct. 25	26	11.9	77.7	Yes.
487	Juneau	Mauston	J. E. Palmer	....do	Oct. 6	34	8.3	69.6	Yes.
534	Langlade	Antigo	F. J. Kubiaczyk	Kleinwanzlebener	Oct. 11	14	10.6	72.7	Yes.
557	....do	....do	....do	Vilmorin's Improved	....do...	19	10	72.4	Yes.
546	Milwaukee	Milwaukee	P. J. Mackeldon	....do	....do...	38	10	73.4	Yes.
480	Outagamie	Appleton	A. Kloes		Oct. 6	45	8.6	65.9	Yes.
270	Sauk	Delton	M. L. Reynolds	Vilmorin's Improved	Sept. 17	35	7.7	67.5	No.
354	....do	Baraboo	M. S. Jip	....do	Sept. 26	22	10.4	74.7	No.
843	Walworth	Whitewater	J. B. Smith	....do	Nov. 6	30	8.9	71.2	No.
	State averages (18 samples).					30	10	73.1	
	WYOMING.								
429	Sheridan	Dayton	R. A. Frazier	Vilmorin's Improved	Sept. 28	17	12.8	79.4	No.
414	....do	....do	....do		Oct. 1	23	14.2	77.6	No.
	State averages (2 samples).					20	13.5	78.5	

Remarks on Preceding Tables.

GENERAL.

The farmers in collaboration with the Division were requested in sending samples to give a statement in regard to the favorableness or unfavorableness of the season. These responses are entered in the last column of the tables. In noting these, it must be remembered that the answers are not based upon meteorological data collected in the usual way, but upon the general impressions which a farmer forms of a season in respect to crop growth.

ARKANSAS.

Only two samples were received from this State, both of which were of inferior quality.

CALIFORNIA.

Four samples showed beets with favorable sugar content, but somewhat inferior to the general standard of the State.

COLORADO.

Fifty-seven samples were received from this State. The average size of the beets was extremely satisfactory, namely, 25 ounces. The content of sugar was high, namely, 14.1 per cent, while the purity was slightly below the standard.

These data, taken in connection with the other reported data from Colorado, show that under irrigation in that State beets of the most favorable character for sugar making can be produced.

DISTRICT OF COLUMBIA.

The samples from the District of Columbia were all grown on the Department farm on the island below Long Bridge. The reports are made according to variety. Six varieties were grown and 13 samples of each variety analyzed, taken at different periods from September 19 to December 11. These beets show a rather remarkable uniformity in comparison during the whole period over which the investigations were continued. In every case the size of the beets was somewhat under the standard which would be favorable to a high percentage of sugar. The sugar content in each case was very low and also the purity coefficient.

CONNECTICUT.

Only one sample was received from Connecticut, and that was of inferior quality.

DELAWARE.

Only one sample was received from this State, which was of small size, but had a high content of sugar and high purity.

GEORGIA.

Only one sample was received from Georgia, and this sample was very small, but had an exceptionally high content of sugar and purity coefficient. The fact that such a beet as this can be grown in Georgia should not be accepted as an evidence of the general fitness of that State for beet-sugar production.

IDAHO.

Nineteen samples were received from Idaho. The beets were of large size with a favorable sugar content and a purity slightly below the standard. The remark made with reference to beets grown in Colorado is also applicable to those produced in Idaho.

ILLINOIS.

Sixteen samples were received from this State. The beets were above the average size. The content of sugar was phenomenally low, also the purity.

This deterioration of the beets from Illinois during the present season is difficult of explanation. In most cases the season is reported as favorable, and yet the beets were the poorest ever received from that locality.

INDIANA.

Fifteen samples were received from Indiana. The beets were of medium size, but the content of sugar was very low, as was also the purity coefficient. The remark just made in respect to Illinois applies with almost equal force to the results of the analyses of the Indiana beets during the present season.

INDIAN TERRITORY.

Three samples were received from this Territory. The beets were above the average size, and the content of sugar and purity were remarkably low.

IOWA.

Thirty-nine samples were received from Iowa. The samples were far above the average size, and the content of sugar and purity do not compare very favorably with previous results from that State.

KANSAS.

Twenty samples were received from Kansas. The beets were slightly above medium size, and the content of sugar and purity compare favorably with previous results from that State, though neither is satisfactory.

KENTUCKY.

Twelve samples were received from the State of Kentucky. The size of the beets was below medium, the content of sugar low, and purity very low.

MAINE.

Two samples were received from Maine. The beets were of medium size, but the content of sugar and purity were remarkably low for beets grown in that latitude.

MARYLAND.

One sample only was received from Maryland. It was below the average in size, with a low sugar content and low purity.

MASSACHUSETTS.

Two samples were received from Massachusetts. Both were very small in size, but the sugar content was high.

MICHIGAN.

Four hundred and seventy-eight samples were received during the year from the State of Michigan, of which Monroe County contributed the greatest number. The average size of the beets was somewhat below the medium. The content of sugar and the purity coefficient were remarkably low for a State which has heretofore given such favorable results.

MINNESOTA.

Ten samples were received from Minnesota. These were above the average size, and the content of sugar and purity were both low for the locality.

MISSOURI.

Nine samples were received from Missouri of average size, but with very low sugar content and purity coefficient.

MONTANA.

Four samples were received from this State. These beets were very much overgrown, and the sugar content and purity were correspondingly low.

NEBRASKA.

Eleven samples received from the State of Nebraska, representing beets of above the average size and with a low content of sugar and low purity.

NEVADA.

Three samples were received from Nevada. These beets were, in every respect, the poorest ever obtained from that locality, being below the average size, and having a remarkably low content of sugar and purity compared with the results previously obtained in this State.

NEW HAMPSHIRE.

Nine samples were received from New Hampshire. The beets were above the average in size, and the content of sugar and purity were not so high as would be expected from the locality.

NEW JERSEY.

Two samples were received from New Jersey. They were of average size, with a sugar content and purity below the normal for successful manufacture.

NEW MEXICO.

Two samples were received from this Territory, of a good size, high content of sugar, but a purity slightly below the standard.

NEW YORK.

Fifty-one samples were received from the State of New York. These beets were of good size, with a high content of sugar and a purity coefficient barely short of the standard.

NORTH CAROLINA.

Four samples were received from the State of North Carolina. These samples were of fair size and with a content of sugar and purity quite satisfactory for the locality.

NORTH DAKOTA.

Five samples were received from this State. These samples were of medium size, but rather a low content of sugar and a low purity for the locality.

OHIO.

Sixty-four samples were received from the State of Ohio. The beets were slightly above the average size. The content of sugar and purity were not high enough for successful manufacture.

OKLAHOMA.

Four samples were received from Oklahoma. These were of medium size, with a fair content of sugar and purity for the locality.

OREGON.

Eleven samples were received from Oregon. These samples were of medium size, with a favorable sugar content for successful manufacture and a purity only slightly below the standard

PENNSYLVANIA.

Eleven samples were received from this State. These samples were of medium size, but had rather a low content of sugar and purity for the locality.

SOUTH CAROLINA.

Three samples were received from South Carolina. They were above the average size, and had a sugar content and purity far below the normal.

SOUTH DAKOTA.

Nine samples were received from South Dakota. These beets were above the average size, and had a sugar content and purity below the normal for that locality.

TENNESSEE.

The only sample received from this State was one of fair quality.

TEXAS.

Fifteen samples were received from the State of Texas. The beets were above the average size, and had a very low content of sugar and purity.

UTAH.

Five samples were received from the State of Utah. They were below the average size, but showed a satisfactory content of sugar and purity for successful manufacture.

VERMONT.

Three samples were received from this State. They were slightly below the average size, but in content of sugar and in purity were just about at the minimum limit for successful manufacture.

VIRGINIA.

Forty-nine samples were received from the State of Virginia. These beets were of medium size, and showed a content of sugar and purity coefficient quite satisfactory for the locality.

WASHINGTON.

even samples were received from this State. They were slightly ve the average size and showed a very high content of sugar and ery high purity coefficient.

WEST VIRGINIA.

Four samples were received from West Virginia. These samples re very small and gave a small content of sugar and a very low rity coefficient.

WISCONSIN.

Eighteen samples were received from the State of Wisconsin. They ere considerably above the average size and showed a very low con- nt of sugar and purity coefficient for the locality.

WYOMING.

Two samples were received from this State. These samples were f average size. They showed a satisfactory content of sugar and a urity cofficient slightly below the standard.

A general review of the data obtained during the year shows that he beets as a whole were of remarkably poor quality as compared vith samples received in previous years. This poor quality of the eets was doubtless due partly to seasonal influences and partly to the ack of proper attention in growing the beets. It is not safe to gen- eralize in particular cases, and therefore in any conclusions which may be drawn from these data the results of previous experiments should be considered. A fairer criterion for the capabilities of the States for beet-sugar production is obtained by a study of the following tables, which contain the averages from the different States and Terri- tories for a period of four years.

AVERAGE RESULTS FOR FOUR YEARS.

In the following table are brought together the average results of the analyses made in this laboratory during the years 1897, 1898, 1899, and 1900. From these a general average for the four years has been secured. Such a general average increases in value as an indicator as the number of analyses and the number of years covered increase. This table shows the number of samples analyzed, the average weight of the beets in ounces, their sugar content, and coefficient of purity. The general average is found by multiplying the data for each year by the number of samples for that year, taking the sum of the

products and dividing by the total number of samples for the four years:

Average results of analyses of sugar beets for years 1897–1900, inclusive, by States.

States.	Year.	Number of samples.	Average weight.	Sugar in the beet.	Purity coefficient.
			Ounces.	*Per cent.*	
Arkansas	1897	2	18	11.3	[illegible]
	1898	6	23	7.1	[illegible]
	1899	5	15	6	[illegible]
	1900	2	9	6.7	61.6
Average for the four years		15	18	7.2	[illegible]
California	1897	1	26	16.8	.....
	1898	4	25	14.6	[illegible]
	1899	1	11	13.9	[illegible]
	1900	4	13	12.9	[illegible]
Average for the four years		10	19	14.1	[illegible]
Colorado	1897	174	20	13.6	[illegible]
	1898	50	22	13.7	[illegible]
	1899	64	24	14.4	[illegible]
	1900	57	25	14.1	[illegible]
Average for the four years		345	22	13.8	[illegible]
Connecticut	1898	4	21	10.3	[illegible]
	1899	2	17	10.9	[illegible]
	1900	1	20	10	[illegible]
Average for the three years		7	20	10.4	[illegible]
Delaware	1898	1	14	11.3	[illegible]
	1899	2	24	12.5	[illegible]
	1900	1	15	10	[illegible]
Average for the three years		4	19	11.6	[illegible]
District of Columbia	1899	4	24	6.4	[illegible]
	1900	78	13.6	8.7	[illegible]
Average for the two years		82	14.1	8.6	[illegible]
Georgia	1898	4	47	5.8	[illegible]
	1899	10	14	11	[illegible]
	1900	1	10	14.2	[illegible]
Average for the three years		15	23	9.8	[illegible]
Idaho	1897	7	21	12.5	[illegible]
	1898	5	28	12	[illegible]
	1899	1	36	10.8	[illegible]
	1900	19	26	13.5	[illegible]
Average for the four years		32	26	13	[illegible]
Illinois	1897	32	17	13.1	[illegible]
	1898	38	20	10.2	[illegible]
	1899	25	25	10.6	[illegible]
	1900	16	27	8.3	[illegible]
Average for the four years		111	21	10.9	[illegible]
Indiana	1897	103	14	13.1	[illegible]
	1898	88	21	10.1	[illegible]
	1899	29	19	11.4	[illegible]
	1900	15	21	9.4	[illegible]
Average for the four years		235	18	11.5	[illegible]
Indian Territory (one year)	1900	3	29	7.9	[illegible]
Iowa	1897	130	18	13.3	[illegible]
	1898	147	25	11.4	[illegible]
	1899	67	24	10.9	[illegible]
	1900	39	33	9.5	[illegible]
Average for the four years		383	23	11.8	[illegible]

Average results of analyses of sugar beets for years 1897–1900, inclusive, by States—Cont'd.

States.	Year.	Number of samples.	Average weight.	Sugar in the beet.	Purity coefficient.
			Ounces.	*Per cent.*	
Kansas	1897	41	27	11.4	73.8
	1898	16	22	10.3	71.3
	1899	35	21	9.5	66
	1900	20	25	10.1	72.1
Average for the four years		112	24	10.4	70.7
Kentucky	1897	6	16	11.9	71.5
	1898	4	14	5.9	61.1
	1899	1	5	7.4	.....
	1900	12	13	8.5	64.8
Average for the four years		23	14	8.9	65
Louisiana (one year)	1900	1	10	16.2	84.2
Maine (one year)	1900	2	19	8.1	67.7
Maryland	1897	29	19	11.4	79.1
	1898	31	22	10.4	76
	1899	6	18	10.2	74.6
	1900	1	10	9.3	74.2
Average for the four years		67	20	10.8	77.2
Massachusetts	1898	4	27	12	78.6
	1899	9	21	14.6	83.3
	1900	2	8	14	.....
Average for the three years		15	21	13.8	81.9
Michigan	1897	450	22	14.7	81.1
	1898	34	28	13.2	81.9
	1899	236	22	13.1	79.7
	1900	478	14	11.3	76.7
Average for the four years		1,198	19	13	79.1
Minnesota	1897	49	24	11	79.2
	1898	21	22	12.7	78.7
	1899	9	23	12.3	77.5
	1900	10	31	10.9	75.9
Average for the four years		89	24	11.5	78.5
Missouri	1897	324	20	11.7	73.5
	1898	43	17	8.5	68.6
	1899	19	17	7.1	64.3
	1900	9	15	8.5	67.2
Average for the four years		395	19	11.1	72.4
Montana	1897	4	20	14.4	77.8
	1898	7	21	11.2	72.6
	1899	2	40	10.7	70.6
	1900	4	38	10.4	69.8
Average for the four years		17	27	11.7	72.9
Nebraska	1897	13	29	12.9	76.9
	1898	10	25	12.8	76.8
	1899	6	19	11.3	74.4
	1900	11	28	9.9	72.1
Average for the four years		40	26	11.8	75.2
Nevada	1897	21	18	18.3	81.4
	1898	42	12	18.5	85.9
	1899	24	18	16.9	82.2
	1900	3	10	9.6	79.6
Average for the four years		90	15	17.7	83.7
New Hampshire	1898	2	34	13.5	83.5
	1899	4	17	15.5	86
	1900	9	29	11.1	74.9
Average for the three years		15	26	12.6	79.0

Average results of analyses of sugar beets for years 1897–1900, inclusive, by States—Cont'd.

States.	Year.	Number of samples.	Average weight.	Sugar in the beet.	Purity coefficient.
			Ounces.	*Per cent.*	
New Jersey	1897	31	16	14.2	[illegible]
	1898	33	20	11.1	[illegible]
	1899	17	27	11.3	[illegible]
	1900	2	20	11.4	[illegible]
Average for the four years		83	20	12.3	78.9
New Mexico Territory	1897	3	18	17.2	[illegible]
	1898	7	20	12.8	[illegible]
	1899	2	22	14.9	[illegible]
	1900	2	23	14.5	[illegible]
Average for the four years		14	19	14.3	[illegible]
New York	1897	225	21	15	[illegible]
	1898	328	21	12.6	[illegible]
	1899	142	19	13	[illegible]
	1900	51	22	13.3	[illegible]
Average for the four years		746	21	13.4	[illegible]
North Carolina	1897	7	23	9.1	[illegible]
	1898	14	19	6.5	[illegible]
	1899	2	17	7.6	[illegible]
	1900	4	23	10.3	[illegible]
Average for the four years		27	20	7.8	[illegible]
North Dakota	1897	4	28	10.5	[illegible]
	1899	3	22	13.9	[illegible]
	1900	5	22	10.2	[illegible]
Average for the three years		12	24	11.2	[illegible]
Ohio	1897	68	22	13.8	[illegible]
	1898	409	24	11	[illegible]
	1899	128	24	11.9	[illegible]
	1900	64	26	10.3	[illegible]
Average for the four years		669	24	11.4	[illegible]
Oklahoma	1897	1	10	11.8	[illegible]
	1898	6	24	10.2	[illegible]
	1899	2	31	10.3	[illegible]
	1900	4	22	10.6	[illegible]
Average for the four years		13	23	10.5	[illegible]
Oregon	1898	6	20	14.1	[illegible]
	1899	1	17	15.8	[illegible]
	1900	11	19	12.4	[illegible]
Average for the three years		18	19	13.2	[illegible]
Pennsylvania	1897	59	18	13.8	[illegible]
	1898	81	21	11.6	[illegible]
	1899	28	31	11.2	[illegible]
	1900	11	21	10.6	[illegible]
Average for the four years		179	22	12.2	[illegible]
South Carolina	1897	13	17	9.9	[illegible]
	1898	4	14	10.2	[illegible]
	1899	4	14	13	[illegible]
	1900	3	29	8.4	[illegible]
Average for the four years		24	18	10.3	[illegible]
South Dakota	1897	5	17	15.1	[illegible]
	1898	24	16	13.9	[illegible]
	1899	11	25	10.6	[illegible]
	1900	9	29	10.5	[illegible]
Average for the four years		49	21	12.7	[illegible]
Tennessee	1897	17	11	10.8	[illegible]
	1898	10	17	8	[illegible]
	1899	2	54	8.3	[illegible]
	1900	1	15	5.4	[illegible]
Average for the four years		30	16	9.5	[illegible]

Average results of analyses of sugar beets for years 1897–1900, inclusive, by States—Cont'd.

States.	Year.	Number of samples.	Average weight.	Sugar in the beet.	Purity coefficient.
			Ounces.	*Per cent.*	
Texas	1897	11	22	12.6	76.5
	1898	49	25	9.5	69.8
	1899	3	12	7.5	53.7
	1900	15	29	6.9	56.8
Average for the four years		78	25	9.4	67.6
Utah	1897	35	20	14.3	81.1
	1898	14	16	13.6	85.3
	1899	10	20	15	83.6
	1900	5	14	13.8	81.3
Average for the four years		64	19	14.2	82.4
Vermont	1897	8	22	14.2	84.1
	1898	68	22	13.2	82.8
	1899	16	23	12.8	79.0
	1900	3	15	12.1	79.7
Average for the four years		95	22	13.2	82.2
Virginia	1897	34	21	11.6	76.2
	1898	43	20	8.9	72.4
	1899	6	17	9.5	74.2
	1900	49	18	10	74.1
Average for the four years		132	19	10	74.1
Washington	1897	34	27	13.7	80.7
	1898	5	27	13.9	81.3
	1899	8	23	13	77.8
	1900	2	24	14.9	85.6
Average for the four years		49	26	13.7	80.5
West Virginia	1897	14	19	15.4	80.4
	1898	4	28	9.1	72.9
	1899	3	20	9.1	67.2
	1900	4	7	10.7	62.7
Average for the four years		25	19	12.9	74.8
Wisconsin	1897	42	15	15.8	83.3
	1898	16	24	13	79.3
	1899	25	21	14.8	84.4
	1900	18	30	10	73.1
Average for the four years		101	21	14.1	81.1
Wyoming	1897	34	19	17.2	82.3
	1898	10	19	13.9	78.1
	1899	1	29	15.9	81.9
	1900	2	20	13.5	78.5
Average for the four years		47	19	16.3	81.2

ARKANSAS.

Fifteen samples have been examined during the four years from this State. The average percentage of sugar in the beet was 7.2, and the average coefficient of purity 63.2. It is evident that sugar can not be profitably made from sugar beets of this character.

CALIFORNIA.

The number of samples from this State was so small as to render the data of little value. The general results, however, confirm the opinion that the capabilities of growing sugar beets of high quality in the State are without question.

COLORADO.

During the four years 345 samples have been analyzed from Colorado. The percentage of sugar in the general average, viz, 13.8, is satisfactory, but the purity for the whole period, 78.2, is slightly below the standard.

CONNECTICUT.

The small number of samples which has been received from Connecticut renders an intelligent judgment, based upon the analyses, impracticable. These results show a character of beets which it would be quite unprofitable to attempt to turn into sugar. The climate and soil of Connecticut, however, are such as to lead to the supposition that beets of good manufacturing qualities could be produced in that State.

DELAWARE.

No valuable deduction can be drawn from the four samples which have been analyzed in three years from Delaware.

DISTRICT OF COLUMBIA.

The results of two years' work show very conclusively that the soil and climate of the District of Columbia are wholly unsuited to the production of beets of high quality for manufacturing purposes.

GEORGIA.

The analyses of fifteen samples from Georgia, extending over a period of three years, give some little indication of the capability of sugar-beet growing in the State. The results, except the one sample received in 1900, are not encouraging.

IDAHO.

Analyses of thirty-two samples from Idaho show the beets to be somewhat overgrown, with a satisfactory content of sugar and a purity slightly above the standard.

ILLINOIS.

One hundred samples have been received from Illinois during the four years mentioned. The average size of the beets was normal, but both the content of sugar and coefficient of purity were below the standard.

INDIANA.

Two hundred and thirty-five samples received from Indiana showed that this State has practically the same rank as a sugar-beet producer as Illinois.

Attention has already been called to the fact that in Indiana and Illinois a successful beet-sugar industry can be established only in the northern parts. It is not advisable to try to push the commercial growing of sugar beets further south than the central portions of these States.

INDIAN TERRITORY.

Samples have been received only one year from Indian Territory and the number is too small to serve as a basis for any rational deduction in regard to the quality of the beets in general grown in that Territory. Its location is such as to render any expectation of successful sugar-beet culture unsuitable.

IOWA.

Three hundred and eighty-three samples were received from Iowa, showing beets of good size and a fair content of sugar, just falling short of the average standard fixed for successful manufacture. The purity of the Iowa beets is remarkably low, when their content of sugar is considered. This fault can doubtless be remedied by more careful culture.

KANSAS.

The climate of Kansas, as has been repeatedly pointed out, is not suitable to the growing of high-grade sugar beets. The summers, as a rule, are too long and too dry. The data which have been secured from the one hundred and twelve samples received from that State confirm this statement.

KENTUCKY.

Twenty-three samples of beets grown in this State have been examined. Their uniformly low sugar content and purity are not encouraging.

LOUISIANA.

Only one sample from Louisiana enters into consideration here. This sample was small in size, but had a remarkably high content of sugar and purity. No conclusions respecting the capabilities of the State for sugar-beet culture can be drawn from this instance. It is interesting, however, to observe that a beet of such fine quality can be grown so far south.

MAINE.

Only two samples representing one year were received from Maine. These samples were remarkably poor in quality. It is interesting to observe that in the two States just cited the data obtained are contrary to the expectations which might justly have been entertained regarding the quality of the beets produced.

MARYLAND.

Maryland appears to be one of those States which is just on the border separating the good from the indifferent areas for sugar-beet production. There are many parts of Maryland where high-grade beets can be grown. This is especially true of the high plateau lands of the Allegheny Mountains. On the Atlantic seaboard, also, beets of high grade can be grown in Maryland. The sixty-seven samples secured from this State showed both the sugar content and purity below the standard fixed for successful culture.

MASSACHUSETTS.

The number of samples which have been received from Massachusetts—namely, fifteen—is too small to serve as a foundation for any definite conclusions. It is evident, however, where the soil conditions are favorable, that beets of high quality can be grown. The analytical data obtained from the Massachusetts samples are very satisfactory, both as regards sugar content and purity.

MICHIGAN.

In the case of Michigan, the number of samples received, viz, 1,198, was so large as to make the deductions therefrom very valuable. It will be seen that the beets were of good size, with a fair content of sugar and a purity almost reaching the standard.

There is little doubt of the fact that Michigan is one of the most favorable localities in the United States for the growing of high-grade sugar beets. When the farmers of the State thoroughly learn the art of successful beet culture, they will be able to compete even with the more favored districts of Europe, both in the quality of the beets produced and in the yield per acre.

MINNESOTA.

The data obtained from Minnesota are not so favorable as theoretical indications would lead one to expect. The analyses of eighty-nine samples indicate beets of very uniform and almost ideal size from the point of view of the farmer and the manufacturer. The content of sugar is slightly below the minimum standard, and the same remark can be applied to the purity coefficient.

MISSOURI.

Missouri, as in the case of Maryland, is one of the border States between the good and bad areas for successful beet culture.

The 395 samples received during the four years showed beets of good average size, with a fair content of sugar but a low purity. The

general result of the study of the data received from Missouri is distinctly unfavorable, and points to the fact that it is not a very suitable region for the successful growing of sugar beets.

MONTANA.

The results obtained from the few samples received from Montana indicate that in the beets grown there so far the percentage of sugar and the purity are very much below the average which might justly be expected.

NEBRASKA.

Many years of the commercial culture of the sugar beet have distinctly fixed the status of Nebraska in respect to this industry. The data obtained from this region show beets of fair sugar content but rather low purity. It has been demonstrated that beet sugar can be made in Nebraska, but it is evident from the data for the last few years that Nebraska does not rank as high as some of the other States in its capability of raising high-grade sugar beets.

NEVADA.

Although Nevada is not regarded as an agricultural State, it is evident from the data secured that if irrigation were practiced over considerable areas there is no State in the Union more favorable to the growing of high-grade beets. In fact, the data obtained from the ninety samples secured from that State are the most favorable of any obtained anywhere in the country. The remarkably high content of sugar in the beet, coupled with the high purity, more than offsets the rather small size of the beet produced. It is evident that in a State like Nevada, where intensive cultivation is essential, no crop could be produced so profitably as the sugar beet, provided the conditions of manufacture are favorable and the factories not too far removed from the sources of supply.

NEW HAMPSHIRE.

The few samples received from this State show beets of fairly high grade. It is not likely, however, owing to the contour of the State and the character of the soil, that beet culture will ever become an industry of great magnitude in that region.

NEW JERSEY.

Eighty-three samples have been received from the State of New Jersey. The size of the beets and the content of sugar were favorable with the purity almost up to the standard. It is evident that portions of New Jersey are favorable to the growing of beets which could be profitably used for sugar making.

NEW MEXICO.

Only a few samples were received from this Territory. The content of sugar in the beets from this region is high, and the purity almost up to the standard. In the commercial growing of sugar beets in this Territory difficulties have been met which have discouraged the growers to some extent, but it is believed that there are many areas in New Mexico where successful beet culture can be carried on.

NEW YORK.

Great interest has been manifested in the State of New York during the last few years in the sugar-beet industry, and three factories have been in operation. Both of the experiment stations, the one of Cornell University at Ithaca, and the State station at Geneva, have investigated the subject of beet culture and have secured data of a very valuable nature.

The data obtained here during the four years are also very favorable, especially so because based upon so large a number of samples, namely 746. While the content of sugar is not phenomenal, it is high enough to make a profitable yield, and the purity is satisfactory.

NORTH CAROLINA.

The samples received from this State showed beets of very poor quality. There are doubtless areas in the mountain regions where fine beets can be grown, but in the lowlands it is evident that the climatic conditions are unfavorable.

NORTH DAKOTA.

The small number of samples received from this State makes any deductions in regard to the beets grown there unreliable. The data, however, when considered with those obtained from the agricultural experiment station, show that successful beet culture can be practiced in North Dakota where the local conditions are favorable.

OHIO.

The large number of samples received from Ohio enables us to form a definite judgment in regard to the possibility of beet culture in that State. The same remark which has been made in regard to Illinois and Indiana is applicable to Ohio. The State as a whole can not be regarded as favorable to beet culture. There are, however, many places in the northern part where beets of high quality could be produced on a commercial scale.

OKLAHOMA.

The data from this Territory are distinctly unfavorable. The conditions which obtain there are very much the same as in Kansas, and the Territory is not suitable to the growth of high-grade sugar beets.

OREGON.

The data from the few samples received from this State are of little value when considered alone. When, however, those obtained from the agricultural experiment station are taken into account, it is evident that in Oregon, at least in certain portions of it, there are areas well suited to the production of beets of very high grade.

PENNSYLVANIA.

Pennsylvania does not hold as high a rank as New York or Michigan in sugar-beet production, but it is evident, from the data secured on 179 samples, that the beets are of a quality sufficiently high to insure favorable results from the manufacture of sugar from beets grown in that State. The great trouble seems to lie with the coefficient of purity. This, however, doubtless can be raised by careful culture.

SOUTH CAROLINA.

The data obtained from this State have been much more favorable than theoretical indications would lead one to suppose. The coefficient of purity in the South Carolina beets almost reaches the standard, while the content of sugar is not so much below the standard as might be expected. Nevertheless, it can not be said that South Carolina is among the number of those States where a successful sugar-beet industry can be established.

SOUTH DAKOTA.

The beets received from South Dakota had a fair content of sugar, but a low purity. It is evident that more careful culture must be practiced in order to raise the purity to the standard. When this is accomplished South Dakota can be considered as one of the localities favorable to beet production.

TENNESSEE.

There are many parts of Tennessee where the altitude is very great, but in these regions water is scarce and the land is devoted almost exclusively to grazing. In the parts of the State where agriculture is practiced it is evident that the conditions are unfavorable to the sugar-beet industry.

TEXAS.

Seventy-eight samples of beets have been received from Texas during the four years covered by the comparison. These beets were slightly above the average in size. They did not, however, show a content of sugar and purity coefficient which would encourage the hope of a successful beet-sugar industry in that locality.

UTAH.

The data from Utah show favorable conditions. In connection with these data, it must be taken into consideration that the sugar-beet industry has been established there on a successful commercial scale. This State can be regarded as one of the most favorable for beet production, and it is likely that a rapid expansion of the industry will be seen there in the near future. The coefficient of purity shows that often under irrigation beets can be produced which have a juice of the finest quality.

VERMONT.

The climatic conditions are favorable to the production of high-grade beets, as is clearly indicated by the data obtained from ninety-five samples. The contour of the State and the character of the soil, however, present difficulties in the way of the expansion of the sugar-beet industry which will be hard to overcome.

VIRGINIA.

The samples received from this State, 132 in number, are not encouraging to the belief that a successful beet-sugar industry can be established therein. There are doubtless many localities, especially in the mountainous regions, where exceptionally fine beets can be grown, but taken as a whole the State can not be regarded as among those where the future will see a successful beet-sugar industry established.

WASHINGTON.

Washington is in the same category as Oregon as a beet-sugar producing State. Perhaps the conditions as a whole are somewhat more favorable in Washington than in Oregon. The data obtained from the forty-nine samples show a high content of sugar and a purity slightly above the standard.

WEST VIRGINIA.

There are many localities in West Virginia, especially among the mountains, where beets of high quality can be produced.

The twenty-five samples received do not correctly represent the possibilities of the State. During the year 1897 there were fourteen sam-

ples received from West Virginia of exceptionally high character. A study of the data obtained during the other three years shows the beets to be of very inferior character.

The agricultural lands in the mountainous areas of the State, where the climatic conditions are favorable, are not extensive enough to allow any considerable development of the industry.

WISCONSIN.

The data obtained from Wisconsin showed that it is one of the favorable States of the Union for the growth of beets.

One hundred and one samples showed beets of ideal size, very high content of sugar, and purity above the standard.

WYOMING.

This State also contains many areas suited to beet culture. The forty-seven samples which have been secured show beets of exceptionally high sugar content and satisfactory purity.

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S. 46.

U. S. DEPARTMENT OF AGRICULTURE.

Report No. 70.

EXHAUSTION AND ABANDONMENT OF SOILS.

TESTIMONY

OF

MILTON WHITNEY,
Chief of Division of Soils,

BEFORE

THE INDUSTRIAL COMMISSION.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
DIVISION OF PUBLICATIONS,
Washington, D. C., July 25, 1901.

SIR: By invitation of the United States Industrial Commission, Prof. Milton Whitney, chief of the Division of Soils, appeared before that body on March 12, 1901, as a witness in regard to the causes of the exhaustion and abandonment of soils. Professor Whitney, in his testimony, gives in considerable detail the causes leading to the abandonment of large areas of land in the New England and Southern States particularly, and in the far West incidentally, together with many valuable suggestions for the reclamation of these deteriorated soils. The subject is of considerable general interest, and it is believed that the republication of the testimony, which also embraces statements relating to other matters allied to agriculture, will serve a useful purpose and enable the Department to meet demands for the information therein contained, upon which there is now no available publication. I have the honor, therefore, to recommend the publication of the testimony as Report No. 70 of the Department.

Very respectfully,

GEO. WM. HILL,
Editor.

Hon. JAMES WILSON,
Secretary of Agriculture.

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EXHAUSTION AND ABANDONMENT OF SOILS.

INTRODUCTION.

At the meeting of the United States Industrial Commission on March 12, 1901, at Washington, D. C., Mr. Phillips presiding, Prof. Milton Whitney, chief of the Division of Soils, United States Department of Agriculture, was introduced as a witness, and, being first duly sworn, testified as follows:

Q. (By Mr. CLARKE.) Will you please give your name and post-office address, and also state your official position?—A. Milton Whitney, Takoma Park, D. C. I am chief of the Division of Soils, Department of Agriculture.

Q. How long have you been in your present position?—A. About six years.

Q. Had you, before coming to that position, been engaged in studies like those you now pursue?—A. Yes; I have been engaged in the study of soils for the past eighteen years.

Q. In how many States?—A. I began in Connecticut at the Connecticut Experiment Station, and was then in North Carolina as superintendent at the experiment farm; then as professor of agriculture in the University of South Carolina; then as professor of soil physics in the Agricultural College of Maryland.

Q. Of what State are you a native?—A. Maryland.

Q. The commission will be pleased to have you proceed in your own way to describe the character of your work in the Department of Agriculture, and especially as to how you gather the soils and how you make your experiments.—A. My understanding was that the main question which would come up would be the very important subject of the exhaustion of soils and abandonment of lands, particularly with reference to the New England States and the Southern States, and incidentally the abandonment of certain lands in the West; to see if cause or causes could be assigned, and if there were any suggestions for remedial measures.

Q. Proceed, if you please, in your own way, then, to develop that particular subject.—A. It is doubtless well known to the commission that there are large areas of land in the New England States that

have been abandoned; that there are large areas in the Southern States that have also been practically abandoned and given over to waste; furthermore, that there are large areas in the far West which have once been settled and which have since been abandoned or are now held in very low esteem.

CAUSES OF THE ABANDONMENT OF SOILS.

EXHAUSTION.

The cause of the deterioration of the lands in the South has been commonly ascribed to the exhaustion of the soil, and this is the first consideration that I wish to take up. The exhaustion of the soil is due, in my opinion, to changes in the chemical and physical properties of the soil rather than to any actual extraction of plant food.

A soil, to be productive, must render annually, as the crop needs it, a sufficient amount of food material in a form available to the plants. As a matter of fact soil is a difficultly soluble substance, composed mostly of silicates and aluminates, or difficultly soluble compounds of silica, alumina, potash, soda, and lime in various forms. Through atmospheric agencies, largely, these compounds are rendered more or less soluble and more or less readily available to plants.

A fertile soil is one in which the weathering effects come in at such times and to such an extent as to render available to plants a sufficient amount of this plant food. If that weathering does not take place and the food material is not brought into a condition in which it is available to the plants, the land is as poor as though it actually contained no plant food.

I have never in my experience seen a case in which one could say with any degree of certainty or even of probability that exhaustion was due to the actual removal of plant food. It is perfectly safe to say that the condition of the so-called worn-out soils in the South is due, not to an actual extraction of plant food, but to the chemical condition in which it now is, in which it is unavailable to plants, and that the restoration of the fertility of that land must be, not necessarily in the addition of plant food to the soil, but in bringing about such changes in the physical conditions or in the chemical combinations as will encourage that natural weathering of the soil which brings the plant food into a condition in which the plant can get its support.

To emphasize this statement, which may appear at variance with the general ideas concerning the exhaustion of soils, I would call the commission's attention to the many cases in which soils have been cultivated for hundreds and thousands of years. So far as we know, within historic times they have been constantly cultivated, and cultivated in the same crops. We have the case of the soils of India, which tradi-

tions say have been cultivated for two thousand years, under primitive methods, without artificial fertilizing, and which still give fair returns of the common crops of the country. We have the case also in Egypt of lands which have been cultivated since history began and where the soils are as fertile as ever. We have all through the southern countries of Europe, and still later in the countries in the north of Europe, in Holland, in Denmark, in France, in England, records of the continuous and profitable cultivation of soils for five hundred years—away back to the time when history first opens up our knowledge of these countries.

There is one phase, however, that it would be well to dilate upon here, namely, that with our increase in density of population and with the competition that has been going on, we are no longer satisfied with the yields that are naturally obtained from many of our soils, and we have resorted to the practice of fertilization in order to force plants to produce far beyond what the natural fertility of the soil will give.

There are historic experiments that have been going on in England for the past fifty years in which a crop of wheat has been grown continuously without fertilization, and the yield has steadily fallen from what it was at first (I forget the figure) until it now produces about 12 or 13 bushels per acre. For the past twenty years there has been little or no difference in the yield, except slight fluctuations due to seasonal conditions, and it is believed that the yield that is now obtained measures approximately the power of the soil to produce a crop under perfectly natural conditions. It will produce annually, so far as we know, for hundreds of years 12 or 13 bushels per acre.

Q. Are you able to state whether the kernel is as full and well developed now as it was in the earlier conditions?—A. So far as we know, the grain is of the same value, pound for pound, but not being satisfied with a yield of 12 or 13 bushels per acre they have, by the use of fertilizers and manures, increased the yield on adjacent plots to an average of about 30 bushels per acre. In this forcing of the crop they have found that they could economically increase the production from that soil. The first we would call the natural fertility and the second the acquired fertility. One is perfectly justified in recognizing these two characteristics in the production of the soil: What it will naturally produce through a course of years under the natural weathering of the material, and what it can be made to produce by the artificial application of more food material than the plant can secure through the natural weathering. If the natural yield from a soil becomes so low as to make it unprofitable, it may often be necessary to fertilize in order to make the soil productive.

DEVELOPMENT OF NEW AREAS AND NEW INDUSTRIES.

The second cause of the abandonment of soils arises from the development of new areas and new industries. There is no question that the opening up of the western country, the great corn and wheat producing States of the central West, the wheat lands of California and of the Red River Valley of Minnesota and Dakota, has had a great influence upon the agriculture of New England and all our Eastern States and has done much toward bringing about the conditions that are now prevalent. This will be taken up more in detail later.

In the line of the introduction of new industries I would cite the case of tobacco: Before the war tobacco was grown very generally in the State of Maryland, and since the war it has been grown extensively in the southern counties only; but with the introduction of the White Burley tobacco in Ohio and Kentucky—which produces a large yield and which can be produced with profit at a comparatively low price—the tobacco industry in Maryland has been largely given up, and the effect of this change on the farmers of Maryland has been very disastrous, because tobacco has been one of the staple products of that portion of the State.

Another instance that I should cite is the development of the truck industry. Fifteen or twenty years ago the truck industry was in a very flourishing condition in Maryland. Truck was grown very extensively on certain classes of soil which were not adapted to other lines, and there were certain localities in which the people were extremely prosperous. But with the development of transportation facilities, with the opening up of truck areas in the South, in South Carolina and in Florida, and with the production of those early vegetables which could be rushed up to the Northern markets in the winter and early spring, the industry has languished in certain localities to such an extent that it has been given up. That is the cause of the abandonment of farms in certain sections of the Atlantic coast States.

Q. (By Mr. KENNEDY.) Are you going to discuss the question of irrigation—whether it will have a still further effect to cause abandonment of poorer lands?—A. I will speak later of the West, but I will bring this in at this time, though I was going to speak of that particularly in connection with the New England States.

Q. You had better take your own order probably.—A. I will be glad to answer any particular question as we go along, though.

ATTEMPTS TO GROW CROPS UNSUITED TO PARTICULAR SOILS.

Another very important contributing cause to the abandonment of lands has been in the unfortunate ventures that have been made in bringing a people from a distance to settle a region with which they are unfamiliar, and to grow crops with which they are themselves

acquainted in the localities from which they come, but which they have no appreciation of as adapted to the localities into which they are going. The Department of Agriculture is constantly in receipt of requests for information as to where certain settlements of people could be made—people who are to be brought in to grow alfalfa, to grow stock, to grow tobacco, or other crops. And very frequently the utmost ignorance is shown as to the localities which are to be selected and as to the conditions into which they are going.

There have been many instances of failure from these causes alone in the States of Maryland, Virginia, Pennsylvania, and in fact throughout the country.

One instance I would speak of particularly that has come to my personal attention is a settlement in one of the Western States. A large area of land was taken up and put under irrigation. Agents were sent from this country abroad to attract immigration. People were brought from Switzerland, from France, from Germany, and an extensive plan of development was outlined. They were to introduce the European grapes; they were to introduce and develop the sugar-beet industry; they were to take up all kinds of fruits that had been successful in their own districts; they were to grow truck crops, and they were to develop large grain and cattle interests. But the plans completely failed, as their soils and their water and their climate were not fit for the industries that they started. After a most disastrous and expensive experience they have lost their crops; they have found that fruit will not grow; that the grape is not suited to the conditions there. They have lost their money, and they have come to a realization of the fact that the country and the conditions are adapted simply to grazing; that if they grow alfalfa and stock they can do well, but they can not do well with their fruits and with their sugar beets, because the conditions there are not adapted to those crops.

Q. Would you state what the location is?—A. It is an area in New Mexico that I am referring to. It is an experience in the Pecos Valley. The principal reason for the failure in that case is due to the condition of the irrigation water. It is very alkaline, which these people did not know when they went into that region. Their failure was also due to their unfamiliarity with the conditions in that locality, and their attempt to grow something that they had grown in Switzerland or in Holland under conditions which were entirely different. In this arid region, where they have to use water to produce any crop, the only available water has been found to be unfit at times for irrigation. This is a cause of the abandonment of large areas of land, not only in New Mexico but in other portions of the West.

UNFAVORABLE CLIMATIC CONDITIONS.

Another contributing cause of the abandonment of lands has been in the selection of localities in which there are unfavorable climatic conditions. The commission is doubtless aware of the conditions in Kansas and in portions of Nebraska and of Colorado—how, during the boom times of fifteen or twenty years ago the country was settled, towns were established, and farms were obtained with the idea that fortunes could be made on the agricultural products of the country. Cotton mills were put up out in the semiarid regions, and are still standing as monuments to the unfortunate schemes and ventures that were devised.

Q. (By Mr. CLARKE.) Could you state what the cause of failure was in that section?—A. Yes; I will come to that.

Q. (By Mr. KENNEDY.) You do not mean cotton mills in Kansas and Nebraska?—A. Yes; there are abandoned cotton mills in Kansas and Nebraska.

Mr. TOMPKINS. There is one at Kearney, I think.

The WITNESS. In explanation of the conditions just stated, it may be observed that the semiarid region of the country extends generally from the one hundredth meridian to the foot of the Rocky Mountains, and embraces in my definition such areas as have from 15 to 20 inches of rainfall per year, but so distributed that only occasionally are the seasonal conditions favorable for crops. When they have a favorable season, or two in succession, as they frequently do, they get fine yields and make good returns, but in three years out of five, when they have their disastrous droughts and get nothing, the profits of the two successful years are entirely used up.

With less than 15 inches of annual rainfall lands are seldom or never successfully cultivated, so far as I know, except in certain areas in Washington and California. With 20 inches of rainfall (that is half what we have in the East), provided it is fairly well distributed, good crops can be grown in the semiarid regions; but it is the uncertainty of the seasons which renders farming unprofitable. It is the uncertain and unequal distribution of the rainfall that has caused so many disasters and has been the reason of the abandonment of so many farms.

It is perhaps one of the most serious problems, that of the semiarid regions, that we have in the agriculture of this country at the present time. In the far West such conditions can be overcome where irrigation is practicable, but so far as known there is no bright future for irrigation in much of the semiarid regions of the country. In Kansas there were in 1889 only 20,000 acres of land under irrigation. In North Dakota, South Dakota, Nebraska, Kansas, and Texas there were only 67,000 acres of land under irrigation in that year, and the possibilities of getting water are small in comparison with the vast areas that would need to be watered to be permanently and safely productive.

Another cause that has contributed to the abandonment of lands in the semiarid regions has been the deterioration of the ranges and the consequent injury to the cattle industry. A division of the Department of Agriculture is actually giving its attention to the investigation of the range problem and the possibilities of conserving and maintaining the ranges, and this being the case, it would hardly be proper for me to discuss this subject at greater length here. It seems to me, however, that it will be necessary and wise to adopt some legislation to protect the ranges in the West, and to prevent the terrible destruction of property which is going on through close grazing, against which there is no restriction in many of the areas of the West. It seems to me that this is a problem for legislation, as it is at present too difficult for the agriculturist to deal with and much of it occurs upon the public domain. Where range lands are rented for 5 cents an acre little expense can be put upon them for improvement. There is little chance at present to make any improvement in the agricultural conditions where land is so cheaply rented, so cheaply purchased, and so carelessly used.

Another example of unfavorable climatic conditions may be cited in the Connecticut Valley, right here in our Eastern States. With a rainfall of about 40 or 50 inches, we have soils that have been abandoned from the same unfavorable climatic conditions—a deficiency of rainfall—as prevail in the semiarid regions of the West. I refer particularly to the Windsor sand, which occasionally produces a very fine crop of tobacco, but the soil is so coarse and leachy that it is only about two years out of five that the conditions are favorable. In the favorable years they get good yields and the farmers are very prosperous and contented; in the other three years out of five, as in the West, the soils dry out and are subject to such disastrous droughts that they are entirely unproductive. The expectation of getting a crop even two years out of five has induced many farmers to hold on until finally there have been successive seasons of failure, and they have had to give up. Under conditions of well-distributed rainfall the soil produces, as does the semiarid land in the West, but it is a desert for three years out of five.

Q. (By Mr. PHILLIPS.) About how extensive is that area?—A. The area in the Connecticut Valley is not large, but along the Atlantic seaboard, in the aggregate, it covers a large area. These coarse, sandy soils are found from the New England States all the way along the Atlantic seaboard and around the Gulf, and many farms have been abandoned on these areas simply because of the unfavorable climatic conditions for these particular soils when other soils surrounding them are favored by the same conditions.

I would cite also another instance to show the effect of unfavorable climatic conditions on the abandonment of soils, namely, the orange

industry in Florida, where they have grown oranges with great success for years and where the industry has flourished in the most promising way until a season of frost and freezes that has thrown back the industry for years and has ruined a large number of people. This is a contributing cause to the abandonment of lands, which can not be overlooked in the consideration of the subject.

SCARCITY OF WATER IN DESERT COUNTRY.

Another cause for the abandonment of lands is found in the scarcity of water in our desert countries. The public lands of the arid States amount to 560,000,000 acres. Only 3,600,000 acres were irrigated in those States in 1889 and only 74,000,000 acres are capable of being irrigated, according to the most careful estimates of the Geological Survey. We have, then, the difference between the possibilities of 74,000,000 acres and the actual extent of 560,000,000 acres, which are used to some extent for grazing lands, and upon which living is, at the most, extremely precarious. Many areas have been abandoned which have once been settled, simply because of the extreme scarcity of water and the impossibility of producing agricultural crops or promoting agricultural interests.

ALKALI AND SEEPAGE WATER.

Another important cause of the abandonment of lands is found in the alkali and seepage waters of the West.

I would call the attention of the commission to some work the Department is doing in Salt Lake County, Utah. This was one of the earliest settlements where irrigation was tried in our modern civilization of this country. When the Mormons first settled the place they naturally took up the richest bottom soils along the Jordan River. The soils were naturally filled with salts, but with the drainage that was started and from the character of the soils themselves the salts were quickly removed and the lands were in splendid condition for agricultural use.

In the further settlement of the country, in the increase in the density of population, as the settlers moved up on the high lands and the water applied at higher elevations, the seepage of water from the canals accumulated in the low places and brought with it the salts, which accumulated to such an extent in the low places that the first lands, the most fertile lands of the valley, were rendered entirely unfit for cultivation. They were wet and swampy, and they were filled with alkali, and the history of this once prosperous community has been that the people are moving up onto the bench land, and are abandoning soils which were once the most productive in the State.

In the area which we surveyed in Salt Lake County, between the Jordan River and the Great Salt Lake, about 50 square miles of land

has been successfully cultivated under irrigation. Of this, 10 square miles, or nearly one-fifth of the whole area, has been ruined and has been abandoned as worthless and useless, and the injury is progressing. Lands are constantly being turned out which have been swamped with seepage waters and which have been filled with alkali.

This is one of the most interesting and most important problems of the West, and one which I should like particularly to bring to the attention of the commission, because it seems to me that something will have to be done, through either State or national legislation, to stop the injury that is going on.

Q. Have you any theory as to how to stop it?—A. I will go on to state that. The conditions may be briefly stated thus: The canal company, whether organized by the farmers or organized with independent capital, constructs a canal and maintains a certain level or uniform grade, going through all kinds of soils which it may be necessary to go through in the construction of its canal. It happens in the Salt Lake Valley, as in many other localities that we have studied, that this canal goes for several miles through a gravelly soil, in which there is a great deal of seepage and loss of water. The water is plentiful and of good quality, so the canal companies are not concerned with the loss. They have a bounteous supply from the Utah lake, and they are getting good water, free from alkali. But the water in seeping out through this gravelly area is slowly filtering through the soil, carrying with it a relatively large quantity of salts, which are in all arid soils, and are concentrating the salts in the lower lands and are filling up the low-lands with water, until, as a matter of fact, there is a string of lakes out in what was once an arid, desert country—artificial lakes on what were later fertile and well-cultivated soils, and which are now abandoned lands and tule swamps.

It seems to me that the farmers situated on those lower levels should have recourse, through civil suits, to damages, and the canal companies maintaining canals under such conditions should either be compelled to protect their canals from seepage or to pay damages to the farmers whose lands are ruined.

These conditions are exceedingly pernicious. If you have a soil under the most careful methods of cultivation, farmed with the most expensive varieties of fruit or other farm products, taking the utmost care, giving the greatest attention to all methods of growth so far as your experience and your skill or the knowledge of your experts will indicate, it is certainly most exasperating to have the land swamped and filled with alkali from a leaking ditch situated perhaps 3 or 4 miles away, and over which you have no possible control. It is an exceedingly pernicious thing, for which some recourse should be had in damages. But, so far as I know, there is nothing to stop it. The lands are going to waste, and one-fifth of the irrigated lands of that district

alone have been abandoned from this cause—a cause which could have been provided against. These lands could have been protected and these farms could have been saved.

Another instance that I would cite in connection with this district is the extensive area that is situated just west of Salt Lake City and extending over to the Great Salt Lake. There is an area of about 90,000 acres, and it comes close up to the Jordan River and extends across to the Salt Lake. The land is filled with alkali, but it is not always apparent on the surface. Frequently the surface looks like a fertile, easily cultivated loam, and many attempts have been made to settle the country. Many farms have been laid out, canals have been constructed, water has been let onto the places, town sites have been located, railroads have been projected and built, and with the first application of water good crops have been produced; with the second, a failure. With the third application the land has become so salty that it is abandoned as a waste and desert land. Thousands of dollars have been invested in the settlement of that tract, and thousands and thousands of dollars have been lost in the fruitless effort to build up an agricultural industry in that area, and this is the cause of the abandonment of these soils—because of the occurrence of alkali not always seen from the surface, but always lying in the lower depths of the soil ready to come up at the first application of water. It will be interesting to state that the result of our soil survey convinced us that it was perfectly feasible to reclaim these lands. There is sufficient fall to put in a drainage system. The soils are naturally easily worked. The expense would be no greater than the drainage of lands in Ohio and Illinois, and the profit that would be realized from the reclamation of the 60,000 acres of land situated on that tract would amount, in our opinion, to about $3,000,000 in property valuation. Now, a very singular thing has arisen in regard to that section, that while the people seem to realize that drainage may reclaim the lands, yet they seem to be averse to having the drainage work done, and the people who have desired to follow our advice have been unable, in certain cases at any rate, to do so from the objection of their neighbors. There are no drainage laws, as there are in Illinois and others of our our Middle States, and the enterprise is stopped right here by the inability to have any recourse to State laws, and by the unwillingness of the people to give access to the drainage canals through their places. This is a matter that I shall refer to later in my remarks upon drainage.

Q. (By Mr. KENNEDY.) Where does the water for irrigation come from—is it mountain drainage?—A. The water is from the mountain streams, fed in this case into Utah Lake, which is a fresh-water lake, and is taken out of the Jordan River.

Q. (By Mr. FARQUHAR.) What is the elevation between the Great Salt Lake and the river?—A. Twelve feet between the level of the

iver at Salt Lake City and the lake, but there is a ridge going through he district that gives about 2 feet per mile of fall on either side, and n addition to that there are extensive washes that extend up through he land that would form natural outlets to the drainage system. They run up for 8 or 10 miles into the country.

Q. (By Mr. KENNEDY.) Is the recession of the waters of the Great Salt Lake having any effect on the soils and climate of Utah?—A. It s having a great effect upon the soils. The level of the Great Salt Lake has fallen 14 feet since 1865, and in our survey this year of the area around Ogden we mapped in 60,000 acres—about 10 square miles area—where the lake had receded, and we established the shore line of the lake in some places 9 miles beyond where the former survey had placed it.

Q. (By Mr. PHILLIPS.) What is the cause of the fall of that lake, in your judgment?—A. There is an annual fluctuation that has never been explained, and there are periodical fluctuations that have never been explained. The level has been known to vary from period to period for reasons that are not at present known, but in addition to that the withdrawal of a large amount of water that is being used now for the irrigation of the surrounding lands, which does not go into the lake as formerly, is certainly a very large contributing cause to the lowering of the present surface.

Q. You spoke in regard to canals through the sandy soil portion, saying there ought to be something done to remedy the evil. Have you any theory? Could the water be carried through pipes and thus prevent seeping through the soil?—A. I would state that in California, where water is more valuable, where the companies themselves are financially interested in how much water they sell, it is very common to protect canals from loss by seepage by running through wooden troughs or through wooden pipes, or as is frequently done where the water is carried through sandy areas, by cementing the sides and the bottoms of ditches. We have photographs (I wish I had brought them with me) of large-sized canals and laterals, constructed in California, with the sides and bottoms cemented.

Q. That would be entirely practicable—to prevent seepage and thus prevent the destruction of lands below?—A. It is entirely practicable. In many cases simply the puddling of the canal would be sufficient, but where seepage causes injury by alkaline deposits, in my opinion, it should be stopped, and the companies should be required to protect their canals from undue loss.

FLOODING AND INUNDATION BY STORMS AND TIDES.

Another cause of the abandonment of land is flooding and occasional inundations by storms and tides. The commission, of course, is well aware of the enormous losses from floods in the Mississippi Valley, and

from the recent floods in Texas. This is a matter of such common knowledge that it hardly seems necessary for me to dwell upon it as one of the important causes of the abandonment of soils, where the conditions are so unsafe that settlers can no longer risk their lives or their crops. But I would call your attention also to the vast extent of the tide marshes and inland swamps of the United States. This question of the tide marshes has recently been brought to the attention of the Department of Agriculture from its economic importance in the New England States. It is estimated there are 168,000 acres of tide marshes along the Atlantic and the Gulf coast; and on the Pacific coast it is estimated that there are several million acres of tide marshes. These lands, if protected from the tide and drained, would be of value in agriculture. Some of the inland swamps of Illinois which were selling originally at $1 to $5 an acre have a value now from $60 to $100 an acre. It is estimated that one-fifth of the area of Michigan is swamp land, which, if drained and reclaimed, would be of great value for celery and corn and potato crops. The tide marshes have also an indirect effect upon the values of adjacent lands, because of the prevalence of disease and the prevalence of mosquitoes. I would not say tide marshes only, but all marshes. The commission, of course, is aware of the commonly accepted views now that malaria is conveyed by mosquitoes, and the Department of Agriculture has been applied to recently from many sources to suggest means of reclaiming the tide marshes and the inland swamps of the United States, partly for their agricultural value and partly for the increase of the healthfulness of the surrounding land. There are many cases where areas and industries have been abandoned from the unhealthfulness of the neighboring marsh lands. I do not know that there is any cause that has contributed so much to the discomfort of many of the Atlantic coast States immediately upon the water, which would otherwise be a delightful location and a fine farming land, as the prevalence of malaria and similar diseases. That these causes have prevented to a large extent the settlement of some of our Southern States and have been the cause of abandonment of some others of our lands is unquestionably true. The prevalence of malaria and these malignant fevers near swamp lands of the South, the unhealthfulness which almost prevents the residence of white persons, is a matter that calls for very great and grave consideration, and it is one that the States, at least, it seems to me, might well consider.

An instance that I would cite as to the effect of inundation and floods as a cause of the abandonment of soils is in the rice lands of South Carolina. These lands before the war were protected by substantial levees that were built through cooperation between the individual and the State and maintained as a protection against the flooding of the fertile swamp lands by floods or by tides. During the period of the

civil war these levees were destroyed, the lands were for a time abandoned, and since that time it has been impossible to get labor to work in the canals, and it has been expensive to construct the levees, and large areas of this once fertile and extremely productive soil have been abandoned from this cause.

Q. (By Mr. CLARKE.) Why has it been impossible to get labor to reclaim this land—on account of unhealthfulness of the climate?—A. On account of unhealthfulness and the unwillingness of labor to work under conditions they have to in the swamp lands. In a way it would seem that machinery could be introduced, dredges; but so far as I know this has not been done on any extensive scale.

Q. Have you given attention to the development of rice growing in southwestern Louisiana?—A. Yes. The conditions there are that these lands, which were semiswamps, have been drained where necessary, and they are not subject to overflow, as the rice lands of South Carolina are. The Louisiana lands are higher, but still they are swamp lands, and the irrigation that is given to these lands is done by pumping or by artesian flow, usually by pumping, whereas the irrigation of the rice lands of South Carolina is from the rivers, and is without any pumping or artificial means, either for irrigation or for drainage.

Q. It is in evidence before the commission that the Louisiana rice region is very healthful.—A. That region is much more healthful than the South Carolina rice lands.

LABOR AND EXPENSE OF MAINTAINING PROPER PHYSICAL CONDITION.

Another cause of the abandonment of lands, at least a contributing cause, is the expense of maintaining the proper physical conditions. The trouble and expense of clearing the stones off the New England fields have been so great and so laborious that they have had something, at least, to do with the abandonment of lands in that locality. The simple expense and labor involved in getting the fields into condition and maintaining them in condition to cultivate in competition with the large areas of the fertile Western plains have been so great that they have unquestionably been a contributing cause to the abandonment of the soils. And the labor and expense and risk in maintaining the proper conditions of the rice lands of South Carolina, which I will refer to again, have been so great that there also these factors have operated against the continuance of the culture of the lands, and have been an insurmountable obstacle to the reclamation of what were once fertile and well-cultivated soils.

TRANSPORTATION CONDITIONS.

I would mention also the effect of transportation facilities. While cheap transportation has opened up new and important markets, it has also been the cause of the development of extensive areas of new and

exceedingly fertile country. The effect of this cause alone in the New England States and in the South has been very great, and will be referred to in a later place.

Another cause has been unquestionably the discrimination in rates and the high freight charges which have prevailed in certain localities. It is not my purpose to go fully into this question, as the commission has had in evidence before questions touching this important subject, but in my experience the commercial value of farm lands is often controlled to a considerable extent by the rates of freight which are locally applicable to these areas. It may be that the lands are situated at such a distance that cheap transportation can not be offered; it may be that there are conditions of expense in the marketing of the products, but certain it is that the possibilities of building up industries, agricultural industries, on certain soils and under certain climatic conditions which in themselves would be favorable is prevented by the impracticability of marketing the products with any profit under the prevailing conditions.

Q. (By Mr. PHILLIPS.) What section of the country is that most applicable to?—A. I would cite, in the case of Florida, the marketing of the bulky and tender products from the truck fields. These products have to be marketed under peculiar conditions. They have to be rushed to the Northern markets on the fast freight or passenger schedule. They have to be provided with proper refrigerating and ventilation cars, and they must be placed upon the market in the shortest possible time in order to be in fresh eatable condition, and to reach the market at the earliest possible date. Now, it is the common experience in Florida that the possibilities of marketing the crop with any profit to the farmer is a pretty close thing to figure on, and that it requires very nice and very close calculation in many cases to determine whether it is possible to send a crop to the Northern markets with any profit. I do not mean to say that there is discrimination, but I do want to show the commission that the possibilities of marketing the crop, the possibilities of transportation, have necessarily something and in many cases much to do with the possibilities of the development of any particular agricultural district, and that that is one of the important factors in the abandonment of many enterprises that have been started—in the abandonment of lands.

Another cause of this same kind which could be cited is in the marketing of the truck crops of southern Maryland. The development of the truck industry there a few years ago was very great, and the product had to be sent by river steamers to the railroad centers, or to the Northern market, and they were picked up by these steamers on their regular runs. The amount of product was large, the distance from the market was great, and the time that was consumed in getting the crop loaded and delivered in the Baltimore or Washington or Phila-

delphia markets became so great, and the transportation service was so irregular, that the industry on large areas has been given up for that one cause, namely, the inability to market the products in the proper way and in the quick time that is made necessary by our present transportation facilities.

Q. (By Mr. CLARKE.) You do not think that the difficulty of getting suitable farm labor for this truck farming was a potent factor in causing the abandonment of it?—A. Decidedly. I shall speak of the condition of labor in the South later on. This is an important contributing cause.

SOCIAL CONDITIONS.

To come now to one of the most important problems—the social conditions and growth in manufactures, and the increase in wages.

New England.—In treating this I shall take up specific cases, first, of the cause of the deterioration and abandonment of lands in New England, about which so much has lately been said. So far as I am aware, there is no evidence to show that the New England soils have any less plant food than they had when first cultivated. That is to say, that so far as the chemical analysis would show, they have all of the essential ingredients for crop production. I do not mean to say, however, that the soils are in as high a state of cultivation as they were, because I do not think that is universally the case; but the exhaustion of soils as it is usually considered has not contributed to any great extent to the present condition of the agricultural lands of New England in the two hundred years in which they have been cultivated. It would be impossible, with the record we have of Eastern countries, to conceive that in two hundred years these soils could be so impoverished by the actual withdrawal of plant food by the crops that have been marketed as to make them markedly deficient in plant food. We must remember that the country throughout the New England States has generally a rough, hilly, and frequently a stony soil, with rocks and bowlders and gravel, left from the Glacial period. The expense of clearing and cultivating these rough and rocky soils is considerable. With the development of the fertile lands in the West, with the ease of cultivation and the methods that can be employed, the cost of production has been reduced. The New England farmer can no longer afford to grow the staple farm products. When wheat was bringing $1.25 and $1.50 a bushel, as it was a few years ago, and when hay was correspondingly valuable and cattle a correspondingly important industry, the products from the New England farms were profitable. There is no question that the New England farmers made a comfortable living; but with wheat as low as it is at present, with cattle as cheaply raised as they are in the West, and with hay and

grain as abundant, they have been unable to compete. The contributing cause of this condition has been the small areas which they could devote to any particular crop, and the labor and expense of cultivating and caring for their land. The development of transportation facilities, the lowering of freight rates in the rail and lake and canal transportation, has made it possible to bring products from the West at such a low price that it has been impossible on the rough and rocky New England soils to compete.

Another very important contributing cause has been in the increase in the number and size of factories. It is unquestionable that the social conditions of New England have changed in the past few years—that the growth of the factory system, that the increase in wages, that the lesser cost of the products of the mills, the increase in the number and variety of articles that are considered necessary for comfort and health, the general increase in the cost of living, the general feeling of discontent, and the unwillingness to remain in the quiet and laborious life of the farm have all had their influence.

It seems to me that of all the causes that have contributed to the abandonment of the lands in New England there is no other factor that has been more potent, more important than this one, of the success of individuals in the commercial and industrial lines, and the apparent ease and comfort and luxury of their lives as compared with the laborious and simple life of even the successful farmer.

Q. (By Mr. KENNEDY.) I read in the public press a short time since that the abandoned farms of New England were being taken up again at a very low price; that those who had abandoned them and gone to the West in many cases were returning and trying to get the old homesteads, and that if they could not do that they were buying abandoned farms in the neighborhood, and in one of the New England States, in Massachusetts or Connecticut, there was not now a single abandoned farm.—A. I think there is a reaction going on, but I should think that statement rather overdrawn. Unquestionably, however, I think there will be a reaction, and that the lands will be taken up.

Q. (By Mr. PHILLIPS.) Have not a considerable portion of those lands been taken up by French Canadians in recent years?—A. Yes; they have. One other point I wish to convey to the commission is that the lands in themselves are not worn out; they are in no worse condition. It is other conditions, and not the actual exhaustion of plant food, by which they are affected.

Q. (By Mr. CLARKE.) Is it not a fact that the products of agriculture in the manufacturing sections of New England are worth more to-day than they ever were before?—A. Do you mean of wheat and grain and fruit?

Q. I mean all crops grown by farmers, including of course, truck farming.—A. Well, I should say not, so far as the general farming

goes. Special industries are exceedingly important in the New England States, and I had aimed to speak of that fact in my suggestions for the amelioration of the conditions.

Q. Instead of manufacturing having the effect of depopulating the farms and of rendering agriculture unpopular, is it not true that manufacturing affords so good a market to the farmer near his farm that by changing his agriculture somewhat he finds it more profitable than ever before?—A. Have you not really given the key to the whole situation, namely, that they have not changed their method; they have persisted—farmers are a conservative class—in attempting to compete with the West, when they should have specialized and have met the changed conditions that have confronted them?

Q. My observation, as a New England man, reared upon a Vermont farm and an annual visitor to that State, and somewhat familiar with conditions in Massachusetts, where more manufacturing is carried on, is the reverse of that, and it is that they do conform to existing conditions and are making more money than they ever made before. Now, if I am wrong about that I hope that you or somebody else in the Department of Agriculture can enlighten the country on that subject. A few years ago a Professor Perry, of Williams College, made the statement that one-third of the farm lands from the summit of the Green Mountains in Vermont eastward to the Connecticut River had been abandoned. I contradicted it at the time from personal knowledge. That is one of the most favorable regions in this country. There is scarcely an abandoned farm to be found there, and agriculture near that region, while it has undergone some changes, is more profitable than ever before, and I would like to know why it is. As you say, the soils continue to be fertile and productive, and the markets have improved, and transportation facilities have improved; why is it, then, that the people will persist in claiming that there is a large abandonment of profitable agriculture in that region of the country? I undertake to say that it is not true, but that the exact reverse is true.

Q. (By Mr. PHILLIPS.) Is it or is it not the fact that the price of lands both in New England and the Central States, Pennsylvania, New York, and Ohio, are not nearly as valuable and would not bring as much per acre to-day as they would twenty-five or thirty years ago, or even before the war?—A. Generally, the land values have fallen, but in specific cases they have risen or have maintained their level. And in many cases in the New England States it is unquestionable that very important industries have been created there, notably the tobacco interests of the Connecticut Valley, which we have lately had under consideration, the area of which we have recently mapped; also the truck interests along the Sound, around Providence, around Boston, are very important, and the fruit interests of the Lower Connecti-

cut Valley, particularly the peaches, have all been exceedingly profitable, and I hope I did not convey the impression that I believed myself that there was any such general abandonment of lands as has been frequently stated in the press, because I think myself that there are many industries in the New England States now that are very important. It is certainly our most important tobacco section—the most important for wrapper tobacco—the finest we get in this country.

Q. Is it not a fact that throughout New England when a farm has been abandoned as a home it has been annexed to some neighboring farm and still carried on as a farm? Is not that almost universally the case?—A. I would not say universal, but it is generally the case; yes. There can be no question, however, that, particularly in the last ten years, twelve years, there has been a period in New England in which agriculture has been at a low stage, and that there have been many abandoned tracts, and many people who have moved away. I have tried to show that these conditions are due to causes other than the poverty of the soil, which I do not believe in at all, and that there is no reason why they should not build up the industry of that country and make it as profitable as, and far more profitable by adjusting it to these new conditions, than it ever was.

Q. Now, I would like your estimate of the proportion, the relative importance of the causes which you have named which have contributed to this soil abandonment. Is it not, in your opinion, mainly due to the competition of the more fertile lands of the West—that is, the more easily tilled lands?—A. I should give that as the first cause, and I should give as the second cause, the increase in the factories, and the demoralizing effect of the factory life and of the factory wages upon the farm people. There is a demoralization; it is more a panic than anything else; they have not the mature sense of perspective, the vision of what can be accomplished if they take new opportunities which have come to them. It is common through our Eastern States. It is a restless feeling that their old conditions have been changed, and a lack of that business planning and management that will enable them to fit their agriculture to new conditions.

Q. Do you think that the young men leave the farms in New England for the factories?—A. I think so.

Q. Have you any information on that subject?—A. I speak from my experience in New England. I lived in New England for many summers when I was a youth, and I have frequently visited there, as it is the home of my father. I spent two years at the Connecticut experiment station when these matters were under consideration, and have also done work since in the Connecticut Valley and in the truck areas of Boston and Providence.

Q. It may be true so far as the machine shops are concerned, and a few other skilled manufacturing industries. Is not the reverse true

so far as the textile industries are concerned?—A. I should say that there is a general feeling among the farm boys in New England that they want the higher education. They want to get into and take up the professions. There is a great ambition on the part of the young men to go to an institute and to get into electrical works at the present time, because the young fellows that they may have been acquainted with are now getting high wages; and there is a desire among the young people of New England, so far as I have seen, to get into these commercial and industrial lines rather than remain on the farms, except where they are situated in communities in which special crops and special agricultural interests are being developed.

Q. Is it your opinion, then, that the system of education in New England is defective—that it tends to work against the best interests of agriculture?—A. That is a very difficult question to answer. It is a notable thing that few of the young men who go to the colleges for their so-called higher education attempt in any way to fit themselves for the farm, and a very striking case of that is found in the small number of students who have attended the agricultural courses at Yale University, which has had a permanent endowment for the purpose of agricultural education, and who have gone out from there as farmer boys. Harvard University maintains an agricultural school and a scientific or technical school, but there is by far a greater attendance at the technical school, as there is at the classical college, than there is at the agricultural courses. This is a question, of course, of the effect of education on farm life, which is widespread; it is found in all schools of the country. My own belief is that the education we are giving our boys is not calculated to make the best farmers, and that we are rather leading them away from the farm. I think there is a tendency the other way now, because we are showing that there are possibilities in agriculture that have never before been realized. We are showing them that there are possibilities of making money, for one thing—of earning salaries that are commensurate in every way with salaries paid to professional men. If we get a tobacco expert now we have to pay $3,000 or $4,000. Six thousand dollars is paid to some of the managers of tobacco estates in the South. The practical growers will willingly pay $3,000 or $4,000 to a man who can manage their estates and make them productive; and the same may be said in other lines of agriculture. In fruit and in dairy interests they think little now of paying $4,000 to $5,000 for experts in different lines—men who can make them successful. These possibilities now are opening up to young men, and they see opportunities for remunerative work. We have recently tried to get tobacco experts in the Department of Agriculture, and it has been necessary for us to pay $4,000 to get a man who is qualified for the work. The Secretary has been desirous of having men trained, and I have presented the matter to several young men, and they have

agreed to come at low salaries, $40 a month—young men from colleges, and they are going to put themselves under the direction of this tobacco expert. They are going into the tobacco sheds and are going to learn how to handle the tobacco, and after they have acquired a practical knowledge they are going to have some training in our laboratories in the principles underlying the handling and manipulation of tobacco. The Secretary says, "Train young men for our own use." If we train them to make good tobacco experts they will go out from us at salaries of $3,000, $4,000, and $5,000, just as we have lost men we have already trained. It is the training, it is the ability of these men to produce products wanted now in this highly specialized industry of tobacco that counts.

The young men are seeing these opportunities, and we are able to get them now readily. They are readily coming to the Department because they acquire in our work an intimate knowledge of the operations on the farm, of the judging and classification of soils, of the treatment of alkali and seepage of waters and underdrainage, and of the production and managemant of tobacco, and we are having no difficulty in getting men who have been trained to some extent. Men are leaving positions in which they were getting $1,000 or $1,200 and coming to us for $40 a month for the experience they will get and the value it will be to them. Some of our young men have had offers at $2,500 or $3,000 to go out and protect some of these Western lands from alkali, because they know how to handle the question. We have shown our ability to handle these questions, which are of so much importance to the people. There is one case which I wish to mention later of a sugar factory in California, that we found was situated on a delta plain. The owners have invested something like $3,000,000 or $4,000,000 in this plant, an immense sum, but their lands are underlain by alkali to such an extent that when they begin to irrigate, as they are planning to do now, there is no question in our minds that they will lose their crops and their lands also. Two factories have been shut up within the last two or three years from this same cause. They know that there is danger, and they offered one of our men a salary of $3,000 just because he knew what the trouble was and could handle that matter for them.

A short while ago Japan took one of our tobacco experts from my own Division and gave him $6,000 to go over there to investigate the possibilities of raising and manipulating tobacco. They came again for another of our tobacco experts and offered him $5,000 to go over and develop the interests on the island of Formosa. These things are having an effect on the people. They are seeing the possibilities in these special industries, and in my opinion the young men are turning more to the farm than they have ever done before, simply because there is something definite, there is a purpose, and they are willingly taking positions in the Department of Agriculture and the experiment

stations, because they are getting into practical knowledge of these affairs. They are acquiring the practical methods and manipulations which give them control of these agricultural methods, and they are finding that they themselves can handle these industries now in a way in which they can make good money, or can get positions of trust and responsibility at salaries commensurate with what are being paid in commercial and industrial lines.

Q. (By Mr. CLARKE.) Are many of these branches of agricultural science capable of being taught in the public schools, say, of the grade of high schools and grammar schools?—A. I think so; and yet it is rather difficult to lay out a course or suggest lines of work and of teaching. But it seems to me, as you have asked me my opinion on this question of education, that we want more agricultural schools, and we want, to say the least, no more agricultural colleges. That is, we want the schools right out on the farm lands where the boys work—where they are taught to care for products and for crops. When I want a tobacco expert I can not go to the agricultural colleges and get a young man who has any knowledge of tobacco. I must go to Florida or I must go to Pennsylvania, and I must pick up an otherwise uneducated man, and yet that man will command a salary of $2,000, $3,000, or $4,000. He is not a college-bred man, but yet he is familiar with the manipulation and the details of that work. Now, if I should want to educate a young man in tobacco lines, to be a tobacco expert or to know how to raise tobacco in the Connecticut Valley, for example, I would take him and send him right to Florida, where they have the highest type of skill and industry in tobacco, so far as tobacco is concerned, of any place in this country. They have developed the industry along really scientific lines by their practical men.

Q. Now, most of the high schools of this country, even in the agricultural regions, have a curriculum chiefly devoted to preparation for entering classical colleges. Almost nothing is taught concerning practical farming in any line. Is it your opinion that the curriculum might be changed to the advantage of the farmer?—A. I think in certain cases it could be, and we would be extremely desirous of seeing in certain centers farming schools for the education of farming boys. If such a school were established in Lancaster County, Pa., under the splendid agricultural conditions prevailing there; if the boys could see the methods pursued there; if they could go out and actually learn how to handle stock, how to handle the soil, and how to handle the crops, they would acquire information in this individual locality that would be admirable in fitting them to take charge of estates and of farm lands of their own in other localities.

Q. Boys reared upon farms become familiar with practical methods, but what opportunity is offered to them in the neighboring schools to become familiar with scientific agriculture? How much chemistry are they taught?—A. There is very little.

Q. What do they know about soiling crops and about the various plant foods and animal foods? Is any of that information taught in any of the high schools in this country that you know of?—A. Very little or none in any that I am familiar with, even in the agricultural districts.

Q. Then, when the system of education leaves the leading industry of a region to the work of ignorance and teaches the youth something else, are they not rather compelled to go out, and are not their ambitions led out into other pursuits?—A. Yes.

Q. (By Mr. PHILLIPS.) At present it would be very difficult to have teachers qualified in these various rural districts to teach this. They would have to be educated for that purpose?—A. It seems to me, further, that when these schools are established they do not seem to be satisfied to remain schools; they so quickly aspire to the dignity of colleges, and from colleges to the dignity of universities. Abroad it is much more frequent to see real agricultural schools, a sort of primary school in agriculture, or high school in agriculture, where the school is situated in a farming district and the methods and thoughts are all upon farming lines. You take a young man and put him under those conditions and he is likely to be much more contented to follow in the pursuits of farming than if you put him into a university like Yale University where the farming course, the agricultural course, is looked down upon by all other students. Under such conditions the young men are not generally satisfied to take a course which is popularly supposed to be an easy one and one which does not maintain the rigorous training that the classical and mathematical lines are supposed to possess.

Q. Perhaps we have diverted you most too long. This is very interesting.—A. I wish I had prepared myself a little more on this line. I did not think of this coming into the discussion. It is a matter that I have often thought of, because I was professor of agriculture in South Carolina and always realized that I was not doing my duty, as it seemed to me, in the training of my men, partly because there is no course in agriculture for a professor to take up—he has to make one himself—and, secondly, the opportunities are not presented, it seems to me, to train people with the particular knowledge that is required in any line of agriculture.

I think that in the New England States, perhaps even more than in the Southern States, that restless desire for material advancement and the higher education has been felt because of the more thickly settled condition and other natural conditions which have already been referred to. Another contributing cause to the tendency in the New England States has been the demoralizing effect of the summer boarders. It seems to me there is no question that, while their presence has been a benefit to the New England States in the main, it

has had a demoralizing effect upon the agriculture of the region. Furthermore, the severe climate of New England has been against the development in some cases, and it has had some effect upon the development of the agricultural resources of the area.

It seems to me perfectly evident that the conditions which have contributed in any marked way to the depreciation of land values in New England have been, first, the development of the West and the lower prices for farm products through the development of the transportation systems, and the increase in the number of factories, in the restless desire of all of our people to a certain extent to leave the quiet and laborious life of the farm and enter the busy, hurried world of commercial and industrial activities. It is quite evident to me, however, that the future for the New England States, as for our Southern States, is in the line of specialization. They are close to the markets; they are peculiarly fitted, as they have already shown, for certain special industries; and the line of future development must be in that direction. They must give up all thought of competition with the general farm crops and must look forward to the building up of certain industries which their position, their locality, and their conditions specifically make possible to be carried on.

The one case of the Sumatra tobacco, that we succeeded in growing last year in the Connecticut Valley, that brought 71 cents a pound when the ordinary crop is grown for 20 cents a pound, was a result of soil-survey work, in which we thought that the conditions were favorable on a certain soil in the Connecticut Valley for the production of this tobacco under certain conditions which we brought about, and the result has been successful. So far as we know, there is no other area besides Florida and the Connecticut Valley, and only certain soils in the Connecticut Valley, where this industry can be pursued; and it is unquestionable in my mind that this industry can be built up, and that there is a possibility of producing $6,000,000 worth of tobacco which we now import from the island of Sumatra every year.

I should also mention that the truck interests and the greenhouse interests around Boston are very great. They are enormous industries, and large amounts of money are invested in them and large profits maintained.

Maryland and Virginia.—I come now to the cause of the deterioration and abandonment of lands in Maryland and Virginia.

The exhaustion of the soils, of which we have heard so much in Maryland, Virginia, and the Southern States, is due, unquestionably, to improper and injudicious methods of cultivation and cropping. This will be referred to more at length, under the head of fertilizers, when we come to speak of remedial measures. It is also due to the decrease in value of farm crops, due in turn to the cheaper production in the West and to the reduced cost of transportation, as has been

referred to in the case of the New England States; also to the increase and the development of special industries in other localities—for example, in the production of the White Burley tobacco in Ohio, which yields more per acre, is grown at a less cost per pound, and can be sold at a cheaper price than the Maryland leaf, and has largely taken the place of the Maryland leaf in the foreign markets, particularly in the French and Belgians markets. Furthermore, the changes in the social conditions due to the civil war and the mortgages which are still outstanding against the lands have been a contributing cause to the abandonment or to the deterioration of many of these areas. It has been found possible in many portions of Maryland, with the prevailing crops and methods of cultivation, to obtain a fair interest on the labor and expense of cultivation, but it has been impossible to obtain a living from the land if at the same time the interest on mortgages, which have been running since the war, has had to be met. And I know of once prosperous communities in southern Maryland where they could still be successful, where they could produce sufficient to maintain families without stint and with a fair degree of comfort, but where nearly all the farms are mortgaged as an inheritance of 30 years ago, and it is impossible to support the families and to pay off the mortgages at the same time. Areas now are being abandoned from that cause throughout Maryland and the South.

One of the most important causes of deterioration, however, and I think I should put this first of all, is the method and system of agriculture that prevails throughout these States. The Division of Soils made a careful soil survey with soil maps of two of the counties of southern Maryland this year—St. Mary County and Calvert County—and of Lancaster County, Pa.; and the study of the conditions which have prevailed and the methods, particularly, which have been used in these two areas has been a matter of considerable interest to me. In the first place, I would state that the soils of southern Maryland are in no way exhausted in the sense that that term is generally used—that is, a chemical analysis shows that they have sufficient plant food for innumerable crops and that there is apparently no lack of plant food in the soil. Unquestionably the soil has been abused, the methods of cultivation and of cropping have been injudiciously selected, and the soils are not now as productive as they should be. There is one area in particular of a certain soil with a heavy subsoil in St. Mary County, probably about 40 per cent of the area of the county, that is, in my opinion, as valuable in its way, and in much the same way, as the limestone soil of Pennsylvania. This soil in St. Mary County sells for from $1 to $3 per acre in forest, as it usually is, or for about $10 per acre where it is under cultivation, while the soils in Lancaster County sell now at from $125 to $250 an acre.

Q. (By Mr. PHILLIPS.) That is chiefly for tobacco, is it?—A. Yes; chiefly for tobacco. It is fit for general crops, but tobacco is grown in

places. But on the soil in St. Mary County there have been several good farms that have been well kept up. The Maryland farmer grows on soils in good condition from 15 to 20 bushels of wheat; he grows clover; he grows tobacco, and he gets from 6 to 10 cents a pound for the tobacco. The Pennsylvania farmer grows from 25 to 35 bushels of wheat; he grows clover and grass, as in Maryland, under good treatment; and he grows tobacco, for which he gets from 6 to 10 cents a pound also. He gets the same price, but a larger yield. It is heavier tobacco. Now, from consideration of the crops that are obtained from this southern Maryland area, and of the staple crops and of the yields and values obtained from the soils of Lancaster County, Pa., it seems to me evident that the soils of southern Maryland ought to have a relatively higher value; and the reason why they have not is largely, in my opinion, because of the social conditions and the methods of farming. If you go into the home of a Lancaster County farmer and sit down to dinner with him, he has an abundance of food in great variety. Everything, the chances are, has been grown upon his own farm. The meat has been raised by himself, the vegetables have been grown in his garden or in his fields, the preserves, or whatever they may have for their dessert, have been made by their families from the products of their garden. Even the sugar, the chances are, has been produced on the place, and actually nothing but the tea, coffee, salt, and pepper have been purchased that goes to make up the family meal. The families as a rule are large. They have a good many children. The boys and girls are all brought up to work on the farm. It is the rarest thing that any of them leave the community or leave the farm. They stay there and they marry. It is a common thing for them to settle on a portion of the farm or on some neighboring farm. The farms are small, and labor is all done by the owner and his family. The girls are all brought up to look after the house. There is no expense for servants. Thay have their garden and their fruit. They put up their preserves and their apple butter, and such things for their winter use. We find that very few products are sold from Lancaster County; very few things are sent out of the county except tobacco and stock. And they not only feed up all their corn and hay that they grow to the stock, but they import it often from other States and from other countries, so that they can raise more stock and make more beef and mutton. Most of the products of the farm, including the wheat, which is ground up for flour in adjoining mills, are used on the farm or manufactured there into some sort of product that is sold or is used up in the district. There are manufactures and industries which require to be kept up in the large city of Lancaster and many smaller towns, in which there is a ready market for everything that is produced in the county, and the interesting thing is that this supply and demand is nearly equal, so that very little is sent out of the county and very little is brought in. The

result is that it is a happy and contented and prosperous community. The lands have been handed down from generation to generation for ages and people seldom think of leaving the place. They are a contented and happy and prosperous people.

In Maryland the methods are altogether different. In the first place the Maryland farm is seldom worked by the man who owns it. There is for some reason an unfortunate prejudice which prevails in many localities, at any rate in Maryland, for a man who actually goes into the field and works his land. He usually has an overseer, a man who is paid to look after and direct his interests instead of doing this himself. Frequently he has not even so much control over his interests, and lets his land out to a tenant farmer who farms it in his own way, by his own methods and for a portion of the crop, and occasionally for a money consideration. The crops grown are the ordinary staple crops of general agriculture. They have corn, wheat, and tobacco. The competition from the West and the low prices of wheat and corn make them scarcely profitable. The competition with the Ohio tobacco and the general specialization which has taken place in the tobacco industry, and the necessity of producing something that is peculiarly adapted to a certain market or to a certain demand, has lowered the price of the Maryland tobacco. Now, after the Maryland farmer has raised these three things he has done, as he thinks, the best he can and he has nothing further to consider for his development. The corn is fed mainly to his work stock, and it all goes to that and his own labor. The wheat is sold and sent off the farm in exchange for flour, which he buys at a considerable increase in cost over what it would have cost him if he could have had it ground in his own neighborhood. The tobacco, of course, is sold and goes out in exchange for productions of all kinds for himself and his family. He buys his meat, he buys his groceries, and he frequently buys the vegetables that he should have raised in his garden.

There is no comparison with the conditions in a prosperous community like Lancaster County and the improvident methods that prevail in some of our Maryland counties and Virginia communities. There is no comparison whatever in the economical methods that are employed, and it seems to me that one of the most important contributing causes to the abandonment and impoverishment of the lands in Maryland and Virginia and of many of the Southern States is due to this one fact, that they do not use the same thrifty methods that have marked the success in Lancaster County and in many other counties of the Northern States.

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Professor WHITNEY (after recess, resuming). At the time of the adjournment or recess I had compared the methods and system of agriculture prevailing in the southern counties of Maryland with the

system prevailing in Lancaster County, Pa., and had drawn some suggestions as to the cause of the differences in the land values in the two localities. In following out our soil investigation and the mapping of lands, we find the same limestone soil which is so productive and valuable in Pennsylvania extending down to the Hagerstown Valley of Maryland and down through the Shenandoah Valley of Virginia. They have the same character of soil, essentially the same climatic conditions, and yet the soils of the valley of Virginia are selling today at from $10 to $20 an acre—rarely more than $40 or $50 an acre—while the farm prices in Lancaster County have been maintained about where they were—about as high as they ever have been—and I can not say that this is due to any cause connected with the soil, but conclude that it is due almost entirely to social conditions, to the respect agriculture has in the community, to the thrifty methods employed by the people, and the way in which the occupation is esteemed.

DETERIORATION OF SOILS OF THE SOUTHERN STATES.

Undoubtedly, the system that prevailed for so many years in the South was satisfactory under the conditions prevailing some years ago, but certainly, with the rapid and phenomenal advance and improvement in industrial lines and in the improvement of transportation facilities, the old methods are no longer applicable. The trouble in this case, it seems to me, is a lack of business method, want of appreciation of changed conditions and of business perception of opportunities that could be taken up and made productive.

In the States farther south than Maryland and Virginia there have been other causes which have operated in this same direction. In the first place, the kind of crop and the clean cultivation that have been given to the cotton crop have caused a tremendous oxidation and loss of the organic matter, and the soil is left relatively poor in these organic substances that are necessary for the normal weathering of the soil material and the preparation of the plant food into a form that is readily available to plants. It has also caused in many areas the erosion and washing of lands that has proved destructive to very considerable areas in the Southern States. There is one condition which has also prevailed against the competition with the South in certain lines of general agriculture—that is, the unfavorable climatic conditions for grain crops. The normal yield of grain in the South is about one-third of what it is in the Northern States. This is due to the fact, so far as we can see, that the greater humidity and larger rainfall are bringing about conditions favoring extensive leaf development rather than the production of grain. In the Northern States the cold, frosty nights are liable to occur about the time the plant has obtained its full development, and this condition favors the production of fruit, as is well known in all life functions. Where there is

danger of the destruction of the plant it tends to reproduce itself in the formation of seed. In the Southern States, with the more equable climate, with the higher temperature, higher rainfall, and generally higher humidity, there is a persistent effort to the production of vegetable growth and a distinctly less chance of the production of grain and seeds. While this is natural, it is by no means necessary, for the largest yield of corn on record is from South Carolina, where there was an abundant growth—abundant vegetative growth—which was checked by methods of cultivation at the proper time—that is, the tendency to vegetative growth being checked, the plant produced seed in proportion to the vegetative growth, and the yield was phenomenal; and it has seemed to me at times as though by a change in the method of cultivation—by some mechanical checking of the growth—that the vegetative growth could be checked and the yield could be largely increased. However that may be, the fact remains that the climatic conditions in the South have never been favorable to a large yield of grain.

I have presented to the commission now the principal causes that operate in the exhaustion and abandonment of soils. These several lines, of course, operate in different proportions in different parts of the country. In nearly all localities one or more of the causes that I have mentioned have operated at the same time to produce the deterioration, if not the abandonment, of soils.

METHODS FOR RECLAMATION.

I come now to the conditions of reclamation and certain recommendations that it seems desirable to make.

Q. (By Mr. PHILLIPS.) Before proceeding with that I should like to bring up a question which has been touched upon. You said in the early part of your testimony that in England the soils had not deteriorated; that the growers raised about the same amount on the land in the last twenty years as they had for forty or fifty years—about 15 bushels. Is there anything in the climate favoring England in this respect? Would the climate in Virginia and Pennsylvania have the same power or force? Is it on account of the damp, or are the climatic conditions there different from ours?—A. Yes; the climatic conditions have a great deal to do with it.

Q. Then you would not, therefore, claim that 15 bushels could be raised on good wheat land in Pennsylvania, as is the case in England?—A. No; but what I say is that under given climatic conditions and with a given soil, a soil even without fertilizer, there would be a certain grain yield that would be maintained for a good many years; indefinitely, so far as we know. It might be 5 bushels to the acre or it might be 10, or it might be 15. It happens to be that under the conditions in England in this one experiment it was 12 bushels.

Q. I know of farms that have become quite poor on the hills because of the water. England being more level, perhaps the conditions would be more favorable?—A. In this experiment that I cite, yes; it was conducted on a level tract.

FERTILIZATION.

Q. Pardon the interruption and proceed.—A. The first method that I will speak of in the reclamation of lands, although in my opinion not the most important, is the subject of fertilization. The primary object of fertilization is the improvement or adaptation of soils to the cultivation of any desired crop or crops. As I have shown, all soils have a natural fertility which can probably be maintained under any condition of cultivation for an indefinite number of years. Very frequently this natural fertility is so low that it is unprofitable to raise a particular crop, as so little is obtained from the soil that it does not pay for the attention given to it. Frequently, also, on a very rich soil the aim is to force the crop, and we call it intensive cultivation—that is, we may have a soil which will produce a large crop, and yet we want to force it to produce all it can. It is like the fattening of stock. We can produce a fairly good animal on our ranges, but if we take an animal and feed it up with concentrated food mixed in the proper proportions for a good diet we can put fat and flesh on it which will make it far more profitable than if we had depended upon the natural food of the locality. It is so with soils. We can unquestionably force the fertility far beyond the natural limit and far beyond the ordinary limits of crop production. This we see particularly in the truck crops, where the poor, barren sands are highly fertilized and where large crops are grown from what would naturally be considered a poor soil. In this sense the effect of fertilization is a simple addition of plant food to the soil in such form that the crops can immediately use it. But fertilizers have another effect, that of increasing the decomposition of the soil particles themselves—that is, the mere addition of fertilizers of different kinds may increase the weathering power, and the soil itself will disintegrate and decompose under their influence faster than it would without their application.

The specific objects of fertilizing are to obtain an improvement in the texture of the soil—that is, frequently a wet refractory clay can be made more pliable, more easily handled; drainage is improved. Frequently also loose soil may be made more compact and more retentive of moisture. At times also the influence of the fertilizers is felt more in balancing up the ratio. We have in Maryland and Pennsylvania small areas of lands that are derived from the disintegration of serpentine rocks that carry a large proportion of magnesia; and it has been found that where the amount of magnesia is in excess of the amount of lime plants rarely do well and frequently are an entire

failure. In such case the application of lime simply to reverse the ratio and make lime a predominating ingredient in the soil will restore the fertility of the land. Very frequently also, and probably more often even than we now suppose, soil is acid. It has been found that the soils of Rhode Island are very generally acid, and the addition of lime simply to neutralize this acidity will promote the fertility of the land in a very remarkable degree. This same cause of acidity of the soil is found now to be much more prevalent than we have heretofore supposed to be the case. The fertilizers that are commonly available are farm products—that is, stable manures and green manures, which are used to a very considerable extent and are both exceedingly important in the list of fertilizing materials. Then we have the commercial products, such as guano, ground bone, potash, and then the mineral fertilizers other than lime, and then lime, marls, and gypsum. It will hardly be necessary for me to go into the question of the fertilizer laws. As the commission knows, most of the Eastern States have rather stringent laws about the inspection and sale of fertilizers; and this subject has been taken up by the Department of Agriculture with the idea of having a more uniform system of laws, if possible, and with some idea of having national laws for the interstate commerce and trade. I am not at all sure how far this has gone, and I therefore do not feel competent to speak upon it.

Another series of fertilizing agents is found in the bacteria and other ferments. This newly discovered nitrogen is really a pure culture of bacteria, which have, by reason of their activities in the soil, rendered available the plant food—that is, they increase the weathering of the rocks and also add to some extent (we do not know how much) nitrogen from the air, converting it into some form in which it can be used by the plants.

ROTATION OF CROPS.

Still another method which I would call to your attention by which reclamation of these waste lands can be realized is in the rotation of crops. There is no question whatever but that in general a rotation or a change in the crops grown on soils is of value in preventing undue waste and undue extraction of certain elements of plant food and the undue tendency for cultivation in a particular way, and unquestionably where intelligent rotation of crops can be inaugurated it is one of the most desirable things to do. There are instances, however, in which the same crop has been grown on the same land for many years without any apparent deleterious effect. On the eastern side of the Connecticut River, near Hartford, they have grown the broad-leaf tobacco continuously for 25 years on the same land, and they claim that the quality of the tobacco as well as the yield is as fine as it was at the beginning—even better.

Q. Is that done without fertilizing?—A. No; that is with fertilizing.

Q. (By Mr. FARQUHAR.) Why is it that the tobacco soils of Virginia here are almost worthless to-day for raising anything?—A. The deterioration of the tobacco lands of Virginia is due more to the general methods of cultivation, which have not looked forward to the maintenance of the fertility of the land or to the proper physical conditions. You will find it almost universally believed in Maryland and Virginia that tobacco is a very exhausting crop and has ruined their soils. On the contrary, if you go to Ohio, or Kentucky, or Pennsylvania, or Connecticut, you will find that it is the one crop which they value as a renovator for their soil. This is, in my opinion, due to the fact that they take so much care of their tobacco lands. They cultivate them so carefully, so perfectly, and so thoroughly; they fertilize them so heavily in order to maintain a good yield and a good quality, that the land has actually improved in spite of the relatively large amount of plant food removed by the crop. I think unquestionably it is a matter of culture rather than of any other one factor. If the Virginia farmers took as good care of their land as they do in other localities there would be no suggestion of deterioration of their soils. But they plant tobacco with little or no fertilizer, or manure, usually without much organic matter. They give the land a clean cultivation and leave it exposed for a considerable portion of the year; and the consequence is that it is not maintained in that vigorous condition in which these necessary changes go on as they should, and the soil is said to be worn out. It is not the loss of plant food; it is a change in the physical and chemical condition of the soil brought about by indifferent methods of cultivation.

SPECIALIZATION OF CROPS.

One of the most important methods for the reclamation of abandoned and exhausted lands is in the specialization of crops. By this I do not mean the exclusive growing of one crop without regard to all other conditions, but I do mean the adaptation of the particular crop or crops that the land is best suited to, and specialization in that particular industry. I shall cite in support of this position the truck industry, which has reclaimed vast areas of lands in the Atlantic States. Twenty-five or thirty years ago the sandy soils along the Atlantic coast were worth about $1 or $1.50 an acre. I remember myself well when they were worth no more than this. By the introduction of the truck crops—that is, the growing of vegetables for our early markets—those lands have risen in value until now they are the most valuable soils in those States, selling anywhere from $50 to $500 an acre, according to their location with regard to the water, freedom from frost, and in regard to the markets and transportation facilities.

Q. (By Mr. PHILLIPS.) You do not mean in the primitive state, but

that under a state of cultivation they are worth that amount?—A. Yes; I mean that the same land that was worth $1 an acre is now worth $100.

Q. By reason of cultivation, and not in the natural state?—A. In the natural state. Any soil that is suitably located for truck farming, especially near the water, and where there is a freedom from frost and where the transportation facilities are adequate, is worth that in its natural state.

I should also state a similar fact as to the case of the pineapple industry in Florida. There is a narrow strip of sand along the coast in the southern part of the peninsula of Florida that was formerly comparatively worthless. It is simply beach sand thrown up by the tide in former times, and is in a ridge about 15 or 20 feet high. It is white, like glass sand, and to the Northern farmer would be just as barren and unpromising as anything could be. By the introduction of pineapples these lands have been redeemed, and a very fine variety of pineapple can be grown upon them. They are worth now anywhere from $200 to $1,000 an acre, according as to whether they are set in pineapples or whether they are wild lands. Even the wild lands, covered with the native jungle, will sell now for from $100 to $200 an acre when favorably located. I know of no more striking illustration of the possibility of specialization in the reclamation of waste and abandoned lands than this instance of the pineapple industry of Florida.

Q. Are they fertilized?—A. Fertilized very heavily. The sand is used simply as a medium apparently for the fertilizers that are put on. They would be of no value for general crop, but are of exceptional value for this one crop, because there is no other soil which can compare with them in the possibilities of growing pineapples of the superior quality that is grown on them.

Q. That strip is in the southern portion of the State, is it not; below Palm Beach?—A. Just above Palm Beach. It begins about there. It extends from Jensen down to Palm Beach.

I would also cite the case of the bright-tobacco industry in the South. Many areas that were formerly of little value and considered very unproductive have been developed by the introduction of that industry and are now worth more than they were formerly, and are the most productive and valuable lands in that section. In this case, also, it is a special adaptation of a particular kind of crop to a particular soil. The bright tobacco can not be grown successfully on all soils. It is confined to certain soils with certain peculiarities, and they happen frequently to be conditions which are unfavorable for the general agricultural crops, fortunately.

I would cite another instance of the cultivation of tobacco in the Connecticut Valley. On the light, sandy soils a fine grade of wrapper leaf is produced which can not be grown on the tobacco lands of

Pennsylvania or of Maryland. It is confined to that one locality of the Connecticut Valley and the Housatonic Valley, and is a special industry that seems to be adapted to that place. The introduction in 1865 of the Sumatra tobacco from the island of Sumatra has had an effect upon the tobacco industry of the Connecticut Valley. The fine texture and fine veins and the working qualities of this Sumatra tobacco have been so appreciated by the cigar manufacturers that it has been imported in increasing amounts ever since in spite of the revenue duty of $1.85 per pound on all that is brought into this country. In other words, the cigar manufacturers prefer paying $2.50 or $3 a pound for Sumatra tobacco to paying 18 cents or 20 cents for the Connecticut leaf, although, as far as quality goes, the Connecticut leaf is preferred by many. Now, it has seemed to me that the industry in the Connecticut Valley was threatened. The trade wants this Sumatra type of tobacco, and have been giving but a low price for the Connecticut leaf. One dollar a pound is paid for the Sumatra and $1.85 a pound is paid as duty upon it. We take only the best that they have, and there is more and more a feeling against the use of the domestic leaf.

Realizing this condition and the necessity of successfully competing with the Sumatra tobacco, the Department of Agriculture two or three years ago looked around for the possibility of raising a Sumatra tobacco in this country which would prevent the importation of such large quantities from that island, and we decided to try a particular soil in the Connecticut Valley.

Last year we procured some Sumatra seed and planted it under a shed. This shed was erected at a height of about 9 feet, and was covered with cheese cloth so as to partially protect the plants from the sun and maintain a very quiet and humid air. The tobacco was grown and cured by the methods used in Florida and in Sumatra and Cuba—a combination of the different methods—and it was pronounced by experts in New York and Philadelphia to be fully equal to the Sumatra leaf that is imported. We confidently expect to be able to establish an industry in the Connecticut Valley upon certain soils adapted to this very fine leaf, in which we hope to be able to successfully compete with the Sumatra tobacco, which we import to the extent of $6,000,000 a year in addition to the duties.

Q. Could it be profitably produced by covering the ground with canvas as you describe?—A. Yes; the profits are good.

Q. Could it be produced without the covering?—A. No; that is necessary in order to change the climatic conditions to get the particular growth that we want. Even with the expense of $500 an acre, which we estimate for the first cost, the profits are likely to be large. We estimate this year $1,400 worth of tobacco from our experimental crop of one-third of an acre.

Q. Have you sought any lands in the South where the climatic conditions would be somewhat similar to those of Sumatra without the canvas?—A. Yes; some Sumatra leaf is being grown in Florida, and the growers are getting large yields. Their finest wrappers are bringing from $2 to $4 a pound.

Q. They raise it, then, without canvas?—A. No; with canvas there also. The climatic conditions during the growing season are not very different in Connecticut and in Florida. It is the same hot, tropical weather.

Q. (By Mr. CLARKE.) Is that cheese cloth strong enough to protect the leaves from hail?—A. There is no ill effect from hail, except possibly an exceptional storm. There is no injury from wind or from insects or worms of any kind. The protection is carried all the way down the sides. There is a gate with an opening for men and teams. It is entirely covered with canvas, and it is a perfect protection against all extraneous conditions.

Q. (By Mr. PHILLIPS.) It would be liable to destruction by storm, would it not?—A. In a very severe storm such as they had two or three years ago in Florida, where one of those Gulf towns was destroyed by the floods that came up, they were destroyed to a considerable extent; but ours in the Connecticut Valley last year withstood the most severe storms. Any ordinary storm has no effect on it.

Q. (By Mr. CLARKE.) Can you give the expense of constructing and maintaining these canvas coverings?—A. The first cost is between $200 and $500 an acre. That seems rather a wide margin, but it depends on the cost of the lumber. In the South, where they have the sawmills right on the place and where lumber is cheap, it costs about $200 an acre for the shed. In the North it will not exceed $500 an acre, and the shed will last about five years. The cheese cloth will cost about $100 an acre, and has to be renewed each year.

Q. (By Mr. PHILLIPS.) Is it taken down in the winter season?—A. The cheese cloth is hardly worth preserving.

Q. (By Mr. CLARKE.) Are those coverings for each row or are they broad enough to cover several rows?—A. The covering goes entirely over the field. It is 9 feet high, so that horse cultivation is carried on under the shed just as it would be in the open air. It may be a 10-acre field or it may be a 30-acre field, but the entire field is covered.

Q. Like a great greenhouse, then?—A. It has the effect of a great greenhouse. The sunlight and the sun heat is very much reduced and modified, and the air is a stagnant and moist air, humid, because there is no wind to carry off the moisture or change the air. The conditions there are really tropical. The plants keep on growing, and in the Connecticut Valley they went right up to the top of the roof; that is, they were 9 feet high.

Q. (By Mr. KENNEDY.) What is the ordinary height of tobacco plants?—A. Ordinarily, about 4 feet.

Q. (By Mr. PHILLIPS.) This cheese cloth does not prevent the rain going through?—A. No; it does not prevent the rain, but it does prevent evaporation, and it conserves the moisture so that the crops do not suffer as much from drought as they do on the outside. It is also a protection against frost. Indeed a covering of the kind described has been used very successfully in the cultivation of pineapples in Florida to protect them against frost. It seems to be a method that is coming into very extensive use in the protection of crops under intensive farming. In the production of truck crops it is getting to be used extensively to protect them from frost and to maintain humid conditions and protect from drought on the sandy soils.

Q. In a very large per cent of these the flavor is due to the direct rays of the sun. For instance, strawberries would not be marketable raised under such conditions?—A. No; I should not think strawberries would. There is some sunlight under the cloth covering, but it is not so intense. It is the intense sun in the middle of the day that hurts some of our tender vegetables, unless they have plenty of moisture. Covered, they have the sunlight, but it is diffused and not so intense as it is outside.

The commission is well aware of the important part celery has played in the reclamation of many areas of formerly wet, mucky lands in many parts of the country; also the importance of the fruit industry in the reclamation of what we considered worthless or abandoned lands.

The introduction of peach culture in western Maryland has created an industry there on some of the soils which were formerly of little or no value, and where they are now worth anywhere up to $1,000 an acre. The location and the character of the soil has made it possible to produce a late peach which does not come into competition with the peaches from the Eastern Shore and southern Maryland, and which has a very fine color and a splendid flavor. These soils are of no value for general farm purposes, but they are particularly adapted to the production of peaches which ripen late, and which have a good flavor and a bright color.

The commission is also aware of the success of grapes and vineyard culture on gravelly soils, and it will hardly be necessary to dilate on the importance of this crop as a means of reclaiming such areas. The most valued soils along the Rhine are frequently so destitute of soil covering that they have to be maintained by stonework, and on these very gravelly soils the finest varieties of grapes have been produced. Over a large class of soils, particularly in rocky and stony areas, fruit trees and grapevines have been found a most important means of reclaiming otherwise worthless lands.

There is one consideration, of course, in the production of fruit which must always be considered, and that is the possibility of marketing. That problem has been solved to a considerable extent by

the possibilities of marketing the fruit in a dried or canned condition, and the exportation of dried fruit is to-day a matter of the greatest importance, and one that is increasing in magnitude, especially on the Pacific coast, where large and increasing quantities of fruit are being consigned to China and Japan.

REFORESTATION, PROTECTION FROM FIRES, ETC.

Another important means for the reclamation of poor or abandoned lands is in reforestation and protection from fires and a more rational method of cutting the timber. This is a subject which is being investigated in the Department of Agriculture, where we have our Division of Forestry concerning itself with this one problem; and it is one of the important problems applicable to areas in which there seems at present to be no other means of improving the land.

THRIFTY BUSINESS METHODS.

The question of thrifty methods and efficiency of labor is one that is very hard to deal with. I can not understand how, by education or by legislation or in any other way, thrifty methods can be introduced into certain areas that are at present of little value simply because the methods are not good. Under present conditions, I do not think that any education would make farming in southern Maryland attractive to a young man. It would be discouraging, no matter what kind of education he had, for him to go back and live under the conditions that prevail there at the present time. The social conditions are such that he can not work with his own hands, and he does not have the intelligent or efficient labor to organize and carry out his ideas. He is confronted from the start with conditions that are almost hopeless for the introduction of new methods and of new crops on a scale commensurate with the importance of the work and the facilities at his command.

Q. Is the negro population very numerous in southern Maryland?—A. It is quite large. It is the principal but not the only labor, and not nearly so large as it is farther south. In my opinion the importance of reclaiming large areas of lands is indicated by the necessity of more thrifty methods and more businesslike plans than they have at the present time in the selection of industries and in the cultivation of crops.

Another very necessary means to the reclamation of lands is business methods and organization in the marketing of crops. The success of the truck industry in Norfolk is largely due to the splendid organization and to the means by which the truck farmers place their crops in certain markets, according as the demand may be greater in one or the other. This is an essential thing in truck farming, because the vegetables can not be held over, but must be marketed or sold as soon

as they reach maturity, and they have to be sold for what they will bring. The organization of growers gets regular daily returns of the market conditions in different cities, and they are able to divide their crops and to send a certain portion to this market or to that, according as they think the conditions will stand. It seems to me that this organization and the introduction of these business methods are the most important factors in the reclamation of abandoned areas and the introduction of new crops.

IRRIGATION.

The commission is of course quite well aware of the method of irrigation which has been so important in the reclamation of certain areas in the West. Unfortunately, about all of the available water has been already appropriated and is nearly all in use.

Q. (By Mr. KENNEDY.) Is that true? Governor Steunenberg, of Idaho, told me a week ago last Sunday that the possibilities of the Snake River for irrigation purposes were wonderful, saying they had not begun to use the water of the stream up to its full capacity.—A. That is so in certain cases. It is so in the case of the Yellowstone River also. But nearly all of the water in California and in Washington and in certain portions of Arizona and in the Pecos Valley in New Mexico is now used to its fullest extent. There are other areas in Montana and in Idaho and in Wyoming where there is still some available water, but as a general statement it may be said that the available waters are already appropriated and in use, except, as I was going to say, such as may be added by the construction of reservoirs for the storage of waste waters.

Q. (By Mr. PHILLIPS.) There are very large possibilities in that regard, are there not?—A. Yes; it is estimated that about 74,000,000 acres can be irrigated by the construction of reservoirs.

Q. (By Representative BELL.) What are the possibilities of the irrigated soil?—A. They are very great for special crops, but they are not so very great for our general crops. For instance, it no longer pays to irrigate wheat. The principal crops are the fruit crops of all kinds, and alfalfa for stock feeding, and special industries of that kind. With these special industries the possibilities are enormous.

The average cost of placing land under irrigation, as shown by the last census, was $12.12 per acre, and the annual cost thereafter of maintaining the water was $1.07 per acre of the public lands. Newell estimates that 74,000,000 acres are capable of being irrigated. The cost of the opening of this area, taking the average of previous experiments, would be $897,000,000. But as the methods of applying the water to the land heretofore have been the simplest possible, the cost per acre has been much less than the cost will be in the new areas that are to be taken up, where the water must be stored and carried

over long distances. For the storage of water under the most favorable conditions in Arizona Mr. Lippincott estimates the cost at $4.30 per acre-foot, and as at least 5 acre-feet of it must be stored for each acre in order to provide for two or three seasons of low water, the cost would be about $21.50 per acre. I would call your attention to the basis of this calculation. It assumes that all of the land that could be watered by the storage reservoir shall be actually taken up and put under water. If only half of that area is taken up, the cost would be twice as great per acre; if only a quarter, it would be four times as great, and so on. So this cost that is given in the estimates of the irrigation engineers is the cost provided all the land possible should be taken up and put under water and the rate per acre was paid in to the canal company.

Q. What would be the value of this land after it was put under water?—A. It would be from $60 to $100 an acre.

Q. (By Mr. PHILLIPS.) Notwithstanding the cost of maintaining the water afterwards?—A. Yes.

Q. (By Mr. KENNEDY.) In what localities?—A. Through the arid regions. This example was in Arizona. Lands in Utah are worth from $60 to $100 an acre; and, set out in good varieties of fruit orchards, anywhere up to $1,000 an acre. In southern California lands are worth generally from $50 to $100 an acre, but many of their orchards are worth from $1,000 to $2,000 an acre.

Q. (By Mr. PHILLIPS.) That would be when they were fruit bearing?—A. Fruit bearing, yes; in fine varieties of fruit. The difficulties in the way of the extension of irrigation by the construction of storage reservoirs are the alkali and the silt in the water. There is no question that the amount of alkali in the water is a very serious factor in many localities. In the Pecos Valley it has been found that the alkali increases in amount as they go down the valley to such an extent that in the lower part of the valley the water is entirely unfit for crops. In the storage reservoir in which water is stored above the town of Carlsbad the evaporation is so great that the salts become concentrated in the water, and at the end of a long dry season the water is too salty to be applied safely to the land. This region, by the way, has the highest evaporation of any place in the United States—approximately so. Considerable trouble has been experienced also and losses have been encountered by the storage of alkali waters in California, particularly in southern California.

Q. Is that water obtained in the hills and mountains or from the rivers? Do you not get pure water from the mountain streams?—A. Yes; and the water in Utah is very pure because there are short rivers that come right down from the snow-clad mountains and deliver pure water; but in the Pecos Valley the water travels 200 or 300 miles from the mountains and gathers up these salts as it goes along. The Pecos

River is entirely taken up about 6 miles above the town of Carlsbad, and 6 miles below the reservoir the stream has about the same flow that it has above the reservoir. Frequently out in the Western lands the water is entirely used up before it gets down the whole course of the river, going out in seepage and flowing again into the river after it has been applied to the land. By the time it gets down to its mouth the water is pretty salty.

There is another difficulty in the storage of water in reservoirs that is particularly troublesome in some areas in the West; that is, the amount of silt carried by the waters. In our work in Arizona, where the waters are very heavily laden with silt, we found a soil that has been recognized as a distinct type, which is undoubtedly a sediment left by the irrigation of some prehistoric race. The old canal systems are there and the old irrigation works and the remains of the houses, indicating that irrigation was carried on in some prehistoric time, and the evidences show that this is simply a deposit of sediment or mud from the rivers. The amount of sediment is so great that the people now have great difficulty in maintaining their canals. They have already dug it out and piled it up as far as they can throw it, and it is a serious question now what they are going to do with the canals in certain areas of the Salt River Valley in order to keep them open. It is very generally believed that reservoirs will quickly fill up with the silt in such districts as that unless special precautions are taken to keep them open; and that is an engineering feature that has not yet been satisfactorily solved. In other localities there is no trouble with this silt, as the waters do not carry any great amount. Even if we get water that is free from silt and an absence of salt, there is the further danger of seepage waters and the accumulation of alkali in the soils, as I have already stated.

Q. This accumulation of alkali is only in arid countries? There is no alkali to speak of in the Appalachian Range, is there?—A. No; because the drainage is so great. So much rainfall comes down that it is carried off. The alkali is the natural weathering of the rocks, resulting from their disintegration.

Q. Peculiar to arid regions?—A. Yes; although we have it here in the East occasionally. The mineral springs that we have are due to nothing more nor less than the decomposition of the rocks, and the same cause accounts for the alkali in the Western States. It is the weathering of the rocks being carried off by the water. In the West these decomposed rocks accumulate in the soil and stay there. Our iron springs and our alum springs and mineral springs generally are the products of the weathering of the rock being carried off by the water. But we get no such accumulations here as they get in the West, simply because we have 40 inches of rainfall here, 20 inches of which goes down through the ground and is carried off in the rivers.

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Out there we have a very small rainfall, only about 5 per cent of which ever goes off, and then usually over the surface of the ground.

In the consideration of irrigation as a means for the reclamation of lands, I would call the attention of the commission to the necessity of uniform State laws and the possibilities of national legislation. There are certain phases of this subject which will undoubtedly have to be taken up by the National Congress, particularly with interstate streams and where the streams form the boundaries of adjoining States. But as the Department of Agriculture has a distinct division for the study of irrigation and its laws and methods, it would hardly be advisable for me to go into it at any great length. My own connection with the matter, however, in our study of the soils and of the seepage waters and alkali has convinced me that it will be necessary to use more care in the application of water, not only conserving it for use elsewhere, but to protect from the injurious effects of overirrigation and the accumulation of seepage water and of alkali. I think it is safe to say that in nearly all the irrigated districts twice as much land could be irrigated with the water that is now used, with actual benefit to the soil, provided it was intelligently applied.

I would also refer again to the matter that I spoke of a while ago; that is, the necessity of legislation in the case of soils damaged by the accumulation of seepage water and of alkali from leaky ditches and from overirrigation on neighboring farms. It seems to me that a remedy of some kind must be worked out. It hardly seems fair or just that a person owning a piece of land which he has planted and cared for and upon which he uses the most careful and most intelligent means, should be allowed to be injured by a seepage from a canal or from the careless methods employed on a neighboring farm. It seems to me that either through State or national legislation recourse should be given for the recovery of damages in civil suits.

DRAINAGE.

The next method to which I would call your attention for the reclamation of lands is the subject of drainage. There are many areas of swamp lands and still larger areas of cold, wet clays in the United States that are unproductive or have been abandoned from a small accumulation of water which needs to be removed by artificial means. It is claimed that one-fifth of the State of Michigan is swamp lands. The report of the Illinois board of agriculture for 1894 states that during 1893—that is, in one year—there was laid in the State of Illinois alone 26,985,000 feet of tile drains. Of this, 18,310,000 feet were laid in the northern part of the State, 8,607,000 feet in the central part, and the remainder in the southern part. In the north there were 28 feet of tile to each acre cultivated. In the central part there were 29 feet of tile for each acre cultivated, and in the southern

part 1 foot of tile for each acre cultivated. In Douglas County there were 85 feet of tile for every acre of cultivated land, and in Livingston County 78 feet to each acre. In the eastern part of Livingston County is found the Vermilion Swamp. As late as 1880 lands could be purchased there for $3 to $5 per acre; the same lands, which have since been drained, are now valued at from $60 to $90 per acre for general farm purposes. As a result of this widespread system of drainage as practiced in Illinois and in Michigan, the swamp lands have become the most productive, the healthfulness of the vicinity has been much improved, and the public roads have been kept in much better repair. The drainage laws of Illinois, and in fact of most of the States where drainage is practiced to a considerable extent, are very complete and deal with all phases of the question, from the rights and liabilities of the drainage commissioners of the district down to the minute details which concern the individual. It seems to me that this question of drainage legislation is one of the important questions, at least for the Western country.

Q. What State has the best laws as to drainage?—A. My opinion is that Illinois has the most complete; Illinois, Michigan, Ohio, Wisconsin, Minnesota, and New York.

As a result of our soil investigations in the Salt Lake Valley last year, we found that it would be quite possible to reclaim the large tract of salt land west of Salt Lake City, and perhaps that this should be done by the people; but it was apparent in the first place that if it were done it would have to be done by private enterprise, as the State was debarred by its own constitution from taking any part in internal improvements of that character, as is done in Minnesota and in some of the Central Western States. It was further found that, by reason of the lack of any drainage laws, it would be almost impossible to drain any considerable part of that area without getting the written consent of every individual landowner who would be in any way affected; and strange as it may seem, it was not found possible to get such consent in the attempts that have been made.

PROTECTION BY LEVEES.

Another method for the protection and reclamation is by levees for protection from floods and from tide. The commission of course is aware of the important work of the commission having this matter in charge on the Mississippi River, and it is scarcely necessary for me to refer to it at this time. I have also spoken at some length in regard to the levees protecting the rice swamps of South Carolina and adjoining States.

A question that is assuming some proportions now in this country is the possibility of reclaiming the swamps of the Atlantic and Pacific

coasts. Not only is it desirable to reclaim these lands for their agricultural value, which it is admitted would be great, but for the protection, the help, and the material welfare of the surrounding country. We have a very excellent illustration of the tremendous bearing this question has upon the healthfulness and prosperity of a community by reference to the conditions prevailing here in the city of Washington, where the swamps have rendered almost uninhabitable, at least by the wealthy and well-to-do people, certain portions of this city, and where there is no possible question that the cause could be removed, and an appreciation of property aggregating thousands and thousands of dollars could be effected simply by reclaiming the swamp lands.

Q. Have you any method of or any theory concerning the reclaiming of those lands? The tide comes up the Potomac. How can it be prevented from overflowing?—A. The same method would have to be used that is used in the rice lands of the South, where similar conditions prevail. There should be a levee with gates which will let the water out and drain the land, and will shut when the tide comes up and prevent any access from the outside. With that protection against the rise of the tide, accompanied by the necessary drainage in the soil itself to carry off the seepage waters which come from the surrounding country, the land could be reclaimed and put in a high state of cultivation.

This question has been asked in regard to the possibilities of reclaiming many of the marshes of Long Island and of New Jersey particularly. It has been estimated that the reclamation of the marsh lands in New Jersey adjacent to Jersey City would cost something like $3,000,000. The plans are under consideration now, and, in fact, large areas have already been undertaken in the reclamation of those lands. Also along the coast, particularly in connection with the residents on Long Island and along the Jersey coast, in Delaware and in Maryland, and in North Carolina and in Virginia, the disastrous effects of these swamps are keenly felt by the people who go there to spend the summer near the seashore. Not only are they unpleasant, but they are at times and in places distinctly dangerous because of the prevalence of mosquitoes, which convey malaria, and because of the presence of other fevers that are very fatal or injurious.

A plan has recently been proposed to the Department for the reclamation of a large area of swamp land on Long Island for the purpose of being able to treat the swamp for mosquitoes. They are not able without enormous expense now to control the mosquito pest and the consequent malaria that has come to the locality. They want to see if the land can be diked and subsequently drained, so that they can entirely exterminate the mosquitoes from that locality. It is probable that the plan will be carried out.

It seems to me that such work as that is primarily for the individual

and in the second place for the State. I hardly see that the National Government has any interest or control in the matter. It is certainly not like the development of harbor privileges or the improvement of rivers, for it applies only to the locality in which it is conducted.

Q. (By Mr. CLARKE.) Are you aware of the experiment in reclaiming marsh lands that was made in Marshfield, Mass.?—A. Not particularly.

Q. There the dike had the effect to close the harbor, practically; not but that there was sufficient area of harbor below the dike, but the failure to accumulate a large body of water above that checked the passing out with the ebb of the tide, and resulted in the accumulation of sand bars in the lower harbor, so that the harbor was practically ruined, and there was a great clamor on the part of the fishermen, which finally came to be supplemented by that of cottagers who built along the shore of that small bay, until, finally, the legislature was induced to cut away the diking and abandon the experiment of reclaiming the lands.—A. Oh; it was the outflow of this immense volume of water that filled up the channel?

Q. Yes; so I apprehend that whenever the experiment is entered upon along the shore anywhere to reclaim the marsh lands the question of harbor rights and the like will come in to affect the problem more or less.—A. There is no question that legislation will be necessary, and it is likely to be a complicated matter. It is one that would affect the State, however, and not the National Government, unless it interfered, of course, with the channels of the harbor; then it would be a national matter.

I think that I have covered in these remarks the principal causes of the exhaustion and the deterioration of soils, as I view the question, and I have spoken at some length in regard to measures which should be used for the reclamation of lands. If I have left anything unsaid that should have been said, or if I should have made anything clearer, I should be very glad to answer any questions that the commission may be pleased to ask.

Q. You said something about animalcules in the soils. Is that a comparatively recent discovery, or has it been long known to scientists that soil abounds in animal life?—A. It is comparatively recent, that is, within thirty or forty years, that the bacteria have been recognized and their importance understood.

Q. I have seen a statement that you can take a small tract of soil which is very fertile, and accustomed to produce large crops, and strike it with a pole persistently until you kill all the animal life that there is in it, and that the next year it would not bear anything. Is that correct?—A. I do not think so; I do not think it would be possible to kill bacteria in that way.

Q. (By Mr. PHILLIPS.) You spoke of cultivating bacteria. What process is used?—A. Certain leguminous crops have tubercles on their

roots, which are found to contain large numbers of these bacteria, and by inoculating with this suitable culture medium, they can be cultivated and pure cultures be made. Such cultures are for sale in Germany and to a limited extent in this country, and it is found that certain crops will not grow unless these bacteria are in the soil; therefore many of the leguminous crops, for example clover, will not grow unless there are certain forms of these bacteria in the soil, and by seeding this pure culture over the land, that is, mixing with a little soil, and sowing on the land, the yield may be doubled, or increased even more than that.

Q. The small bulbs are used in producing cultures in the same way?—A. Yes; the tubercle is just mashed in the culture medium, so that the inside is exposed, and these bacteria get out and thrive on this culture medium.

Q. What is used for that culture medium?—A. I am not sure what is used; I am not acquainted with the method of making the pure culture.

Q. (By Mr. TOMPKINS.) That is similar to Conn's culture in giving flavor to butter?—A. To butter or cheese.

Q. Where is this culture made in this country?—A. Some important experiments have been made at the experiment station in Alabama.

Q. At Auburn?—A. At Auburn; yes. Some of the most important work has been done there.

Q. Under whose charge?—A. I do not recollect now.

Q. (By Mr. CLARKE.) Can you ordinarily determine by the examination of soil what is requisite to make it more productive?—A. No; you can not, and that is one of the most embarrassing questions that we have to answer. As I have shown in my testimony, the cause of the deterioration is quite often due to lack of good management, good judgment, and good practice on the part of the farmer, but we can not tell from a chemical or physical examination whether the soil is productive or not. We can often tell the kind of crop it is adapted to, whether it is a truck soil, or wheat soil, or a grass soil, but whether it is fertile in its condition the chemical analysis does not clearly indicate.

Q. Recently Mr. Hammond, of South Carolina, a very intelligent planter of long experience, testified before the commission that in his opinion the use of commercial fertilizers was an evil rather than a benefit, especially in his State, and particularly because it led many farmers to abandon making an application of the ordinary farm fertilizers, manures, etc. What is your opinion about that?—A. My opinion is that in the main that is correct; that the use of fertilizers tends to make the farmer more shiftless and less careful in saving and in the cultivation of his land. Fertilizers have been introduced in comparatively recent years. There was never any trouble for lack of fertilizers in the Eastern countries. The lands there have been culti-

rated for hundreds and thousands of years, but it had been done by careful work. The farmers have saved everything that came off the place. They have saved all of the litter and put that back; all manure and put that back, and all excrements and waste of the farm and put them back on the soil and worked it in; they have had small holdings and used intensive cultivation. With us, we have these large areas, entirely too large to manure with the ordinary waste from the farm, and we rely on these commercial fertilizers with no addition of organic matter, and after with clean cultivation. There is no question in my mind that much harm has been done by continuous and excessive use of commercial fertilizers without the intensive methods that should be employed when they are used.

Q. Would it not, in your opinion, be possible to reclaim very many of the so-called worn-out farms of Maryland and Virginia by gathering muck from the low places and subjecting it to the tread of live stock, and mingling with it the manure that ordinarily accumulates on a well-stocked farm, and applying that intelligently to the various soils of those farms?—A. It would be where the cost of the process would not be too great, but unless it was adjacent to the land it would not be feasible. The cheapest method in that case would be to grow cowpeas and other forms of green manure. There is no question if you adopt such methods as that, of being able to bring the land up. It is simply because farmers do not do what they know is the simplest and most efficient thing to do. There are lands that are kept up in good shape just by the methods that are used on the average farms which are in very good condition, simply because they are attended to in those ways.

Q. Have the farmers of the West begun to practice fertilization a great deal more than formerly?—A. They are not using fertilzers to any great extent. I think the practice is increasing a very little, but very little fertilizer is used throughout the West at the present time.

Q. Is there not danger that their soils will become comparatively barren unless something is done to restore what is taken from them?—A. There will be if the owners persist in the cultivation of the same crop year after year, as is done now in Red River Valley and in some of our Central States; but by a rotation of crops or by introduction of more intensive methods when the soils begin to wear out their fertility can be maintained and improved. Now, they say very justly that while they are getting 12 or 15 bushels of wheat to the acre at the low cost at which it is produced, 20 cents, they don't care at all what becomes of their lands; they are going to last the lifetime of the present generation and they are not concerned with what becomes of them after that. I think very likely that that yield of 12 or 15 bushels that is obtained now in the Red River Valley can be obtained for a long series of years. The soils are almost identical with the fertile wheat lands

of Russia that have produced wheat for a great many generations, but the time will come, I presume, when the yield will decrease below what they are getting now, and they will feel the need either of fertilizing the soil better or of changing their crops and introducing more intensive methods than they have at present.

Q. What is your advice on the subject?—A. I see no opportunity of changing the methods at the present time. It is a good deal like the arrangement made where you can rent range lands for 5 cents an acre per year, and where you can not afford to put much improvement on the lands. They are only worth $1.25 an acre, and you certainly can not spend much money in maintaining the fertility of such lands. It seems to me it is an economic question; it is not an agricultural question. We simply can not afford to maintain the fertility of those lands with the expense attending that process until lands become more valuable than they are at the present time.

Q. It is cheaper, is it not, to maintain fertility than to restore it?—A. That, of course, is a relative matter; it is more expensive for us and it is less expensive for our grandchildren.

Q. Have you investigated the subject of flowing sewage upon the lands?—A. I have not, except quite incidentally. We have never made any investigation of that question at all.

Q. (By Mr. PHILLIPS.) What is the best green crop to raise to fertilize the land—plowing it down, for instance?—A. Clover is one of the best renovators of the soil where it can be grown, but the possibilities of growing it are limited and the most generally useful crop is the cowpea of the South.

Q. That came into use quite recently?—A. Yes; well, twenty-five years ago in an extensive way.

Q. Is it used to a considerable extent in the North and West?—A. It is being used to a considerable extent now in the North.

Q. It is supposed to have this bacteria, is it not?—A. Yes; it has these root tubercles.

Q. (By Representative BELL.) Have you ever visited Greeley in Colorado?—A. I was there once, six years ago.

Q. They have a rotation there on first wheat; then they follow with alfalfa, which they plow under; then follow with potatoes, and in turn follow the potatoes with wheat. They thus grow an enormous crop every year. I think they make over 40 bushels of wheat there to the acre following those crops.—A. And they get enormous yields of potatoes.

Q. Enormous. It is the best potato spot in the world. They haven't a rival in the United States. I think they ship the best potatoes to London.

(Testimony closed.)

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U. S. DEPARTMENT OF AGRICULTURE.

Report No. 71.

SOME MUTUAL RELATIONS BETWEEN ALKALI SOILS AND VEGETATION.

BY

THOMAS H. KEARNEY, Assistant Physiologist,
Division of Vegetable Physiology and Pathology,

AND

FRANK K. CAMERON, Soil Chemist,
Division of Soils.

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WASHINGTON:
GOVERNMENT PRINTING OFFICE.
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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
DIVISION OF VEGETABLE PHYSIOLOGY AND PATHOLOGY,
Washington, D. C., June 24, 1901.

SIR: I have the honor to transmit herewith several papers on Some Mutual Relations between Alkali Soils and Vegetation, prepared by Mr. Thomas H. Kearney, of this Division, who was detailed to the work at the request of the Chief of the Division of Soils, and Dr. Frank K. Cameron, of that Division, and respectfully recommend their publication as Report No. 71 of the Department. The studies so far made in connection with the work discussed in these papers have brought to light some important facts and have opened lines of inquiry which promise to develop methods of dealing with alkali soils that will reduce their injurious effects on crops grown where such soils exist.

Respectfully,

ALBERT F. WOODS,
Chief of Division.

Hon. JAMES WILSON,
Secretary of Agriculture.

LETTER OF SUBMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
DIVISION OF SOILS,
Washington, D. C., June 24, 1901.

SIR: I respectfully submit herewith the manuscript of a report prepared by Mr. Thomas H. Kearney and Dr. Frank K. Cameron to throw light upon problems encountered by the field parties of the Division of Soils in the soil survey of certain areas in the West affected with alkali. As this is treated largely from the physiological side, it seems proper that it should be transmitted by you for publication.

Respectfully,

MILTON WHITNEY,
Chief of Division.

Mr. ALBERT F. WOODS,
Chief, Division of Vegetable Physiology and Pathology.

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SOME MUTUAL RELATIONS BETWEEN ALKALI SOILS AND VEGETATION.

THE EFFECT UPON SEEDLING PLANTS OF CERTAIN COMPONENTS OF ALKALI SOILS.

By THOMAS H. KEARNEY and FRANK K. CAMERON.

INTRODUCTION.

Everyone who is familiar with alkali soils knows that their charac ter varies greatly in different localities, one salt or combination of salts predominating over others which may be present.[1] Sometimes sodium carbonate, the dreaded "black alkali," is relatively abundant as compared with the other soluble soil components. In other cases this salt may be entirely absent or present merely as a trace, while one or more of the "white alkali" salts, e. g., sodium chloride or sodium sulphate, plays the most important part.

It is also known that these salts are not all equally injurious to vegetation. Sodium carbonate, for instance, is generally believed to be much more harmful than any other salt of common occurrence, owing probably to its pronounced corrosive action on the plant tissues. Gypsum, or the dihydrate of calcium sulphate, on the other hand, is harmless and even beneficial in ordinary cases. Experiments with solutions of chemically equivalent strength show very marked differences in the action of different salts upon plant growth. Hence the question whether the salt forming the greater part of the soluble components of a given soil is, to take a concrete case, the very injurious sodium carbonate or the relatively harmless sodium chloride, may often determine whether that soil is utterly useless or quite valuable to the farmer.

It becomes, therefore, a question of great importance to everyone who is concerned with soils which contain an appreciable amount of alkali to know definitely the relative harmfulness of the salts both severally and in mixtures, since the latter is the condition under which they almost invariably occur in nature.

Field observations will give some idea of how the soluble salt components compare in this regard. But the conclusions are necessarily somewhat vague and unsatisfactory; for in the field and under the conditions that are found in nature it is practically impossible to study

[1] See Bulletin No. 17, Division of Soils, U. S. Department of Agriculture (1901).

the effect of any one soil component. It is rare indeed that the "alkali" is composed of but one salt or chemical individual. And, as will be brought out later, it is entirely impossible to predicate anything definite as to the action of a mixture of salts upon a plant from a previous knowledge of the effects produced by each single salt. Conversely, it is equally impossible to draw conclusions as to the action of any one of a mixture of salts from observations of the effects produced by the mixture itself.

The more exact methods of the laboratory are necessary in order to give us precise knowledge, and with this end in view the present investigation was undertaken. It is not claimed that the results so far obtained are in all respects conclusive. The fact that only two species of plants were employed in these first experiments is sufficient indication that they are not. In physiological research nothing is more dangerous than generalization from the behavior of one or a few species of plants to that of plant life as a whole. It is a well-established fact that species differ widely in their reaction to a given chemical or physical condition. Witness the fact that seaweeds will thrive in water containing 1.5 to 3 per cent of sodium chloride, and that salt marshes, whose soil is saturated with water containing nearly or quite as much of this salt, often support a luxuriant vegetation, while the average crop is killed by a much more dilute solution of sodium chloride. Certain plants show a marked aversion to limestone soils, while other species are almost entirely limited to soils having a high content of lime.[1] But it is needless to multiply illustrations of so familiar a phenomenon.

That a similar diversity is manifested by different cultivated crops in their sensitiveness to various mineral salts when present in the soil solutions is well known. Therefore we can not safely predict, until experiments with many different plants have been made, that the order of harmfulness of the alkali salts here established for two plants will be found to hold for all or even many of those which are commonly cultivated in the alkali regions. But, as it is obviously essential to the satisfactory prosecution of alkali soil work that a definite standard for comparison of the salts be established, there need be no further apology for the presentation of these first results of what it is hoped will become an exhaustive investigation.

In the progress of the work numerous data were accumulated which appeared to possess a more than ordinary degree of scientific interest, especially as relating to the chemical theory of the dissociation of electrolytes in solution and to the recently published hypothesis that various salts, or rather their dissociated ions, enter into compounds

[1] The interesting subject of "lime-loving" and "lime-avoiding" plants has been much discussed by European botanists. It is synoptically treated by Drude (Handbuch der Pflanzengeographie, p. 51) and by Schimper (Pflanzengeographie, p. 105). The latter author gives an extensive bibliography.

with the proteids of the protoplasm of plants and animals, which "ion proteids" play a highly important part in life processes and phenomena. This aspect of the subject will be treated particularly in discussing the significance of the experiments with mixed solutions.

METHODS OF EXPERIMENT.

SALTS EMPLOYED.

In the selection of a series of salts for investigation the experience of members of the Division of Soils in field and laboratory served as a guide. Salts were used which have been determined as forming definitely injurious components of alkali soils and as occurring in sufficient quantity to be of practical importance. In about the order of their general abundance in the Western United States these are sodium chloride (NaCl), sodium sulphate (Na_2SO_4), sodium carbonate (Na_2CO_3), sodium bicarbonate ($NaHCO_3$), magnesium chloride ($MgCl_2$), magnesium sulphate ($MgSO_4$), and calcium chloride ($CaCl_2$). Incidentally, experiments were made with gypsum ($CaSO_4 2H_2O$), calcium carbonate ($CaCO_3$), calcium bicarbonate [$Ca(HCO_3)_2$], and with magnesium carbonate ($MgCO_3$), and bicarbonate [$Mg(HCO_3)_2$], as well as with an aqueous solution of carbon dioxide (CO_2), the last in order to test a theory that suggested itself during the experiments with carbonates and bicarbonates.

In preparing and standardizing the solutions much assistance was rendered by Mr. Seidell, of the Division of Soils.

The solutions were invariably made with salts manufactured by Baker & Adamson, and found to be practically chemically pure, dissolved in distilled water.[1] They were made up in each case on the basis of a normal solution—i. e., of a gram-equivalent per 1,000 c. c. of

[1] The water used in all experiments was distilled through a tin worm and was collected and stored in Winchester quart bottles of practically insoluble glass. A conductivity test showed this to be an unusually pure water, but in order to establish this point beyond doubt, a portion of this same water was redistilled from glass, the first and last portions being of course discarded. A test of the distillate showed it to possess about twice as great conductivity as that which had been distilled only once from the tin. A comparison of cultures of lupines in the water which had been only once distilled with that which was redistilled showed practically no difference in the amount of growth made by the roots. As Galeotti has lately shown [Biol. Centralbl., 21, 329 (1901)], the oligodynamic action of relatively concentrated "colloidal" solutions of metals disappears in the presence of weak solutions of electrolytes. Thus a solution of copper containing 1 gram-atom of metal per 126,000 liters of water produced no effect upon Spirogyra in the presence of a 0.01 per cent solution of sodium chloride, and a solution of 1 gram-atom of copper per 63,000 liters of water acted only after twenty-four hours, although in the absence of the electrolyte the toxic effect of the colloidal copper solution is manifested at a dilution of 1 gram-atom of copper per 126,000,000 liters of water. (See footnote, p. 50.) Hence it is practically certain that in the experiments described in this report no complications were to be feared from the possible presence of a trace of metals in the water used.

solution. In other words, in the case of monovalent compounds, one gram-molecule was contained in a liter of solution, while in the case of bivalent compounds, a half gram-molecule was present.[1] In this way only is a really instructive and fair comparison of the effects of different salts obtainable. Many experiments made in times past in which comparisons were based upon simple percentages of solute to solvent by weight are for this reason of far less value than if normal solutions had been employed. In order to study comparatively those effects produced by different electrolytes which are not dependent upon their respective chemical natures, but which are common to them all and due only to their active masses (such, for instance, as effects due to the osmotic pressure existing in the solution), it is obviously necessary to take into consideration the number of reacting weights of the electrolyte introduced and the amount of electrolytic dissociation which takes place. That is to say, one must consider the concentration of the solution with respect to the number of reacting chemical equivalents, molecules, or ions which may be present. Moreover, attempts to study comparatively the effects produced by different kinds of ions in the solution can only be made by approaching the subject in this manner. But in all statements in this report of the concentration of a given solution both fractions of a normal solution and parts of salt to 100,000 of solution are given in order that the results may be readily intelligible to readers who are familiar with one or the other method, as the case may be.

The method pursued in these experiments was to make and carefully standardize a large volume of a normal solution of each salt and then dilute to the required strength as occasion demanded.

In beginning the experiments the limit for each salt as determined by investigators in the field was first tried, but immediately showed itself to be too high. So lower and lower concentrations had to be tested until the critical one was reached.

PLANTS SELECTED FOR EXPERIMENT.

For a variety of reasons the white lupine (*Lupinus albus*) was employed in nearly all the experiments, although subsequently alfalfa (*Medicago sativa*) was introduced for comparison. The lupine has a seed of good size, averaging 10 to 12 mm. in greatest diameter. As an abundant supply of nutritive material is stored in the thick seed leaves, there is no danger of starvation of the seedlings in experiments of short duration such as those here described. The lupine seeds germinate readily, sending out a vigorous radicle with clean,

[1] Dandeno [Bot. Gazette 32, 229 (1901)] has recently called attention to a certain amount of confusion which has existed among both chemists and physiologists as to the preparation of a normal solution, and it has seemed wise to describe in detail the procedure followed in this investigation.

bright, white surface. If the seeds are germinated in a proper medium (sphagnum or peat moss saturated with water was actually employed) the root is usually straight or nearly so. These characteristics are important, as they permit the easy and accurate measurement which is essential to a determination of the amount of growth made during a given period. The white lupine has the further advantage of being a favorite subject for experiment with plant physiologists, so that numerous data for comparison are available.

In one series of experiments lupine plants were used which had been grown for eleven days in a prepared culture solution, and had not only developed a considerable root system, but had unfolded two or three leaves in addition to the seed leaves. In these plants all the processes essential to the life of a mature individual were undoubtedly in full activity. As a rule, however, a much earlier stage of growth was preferred, as clearly affording a more sensitive index of the effect of solutions. Experiments with older plants indicated that they are less delicate registers of toxic effect. An additional advantage in using very young plants is that they are practically independent of the substratum so far as food supply (that is, the mineral ash constituents) is concerned, that stored in the thick cotyledons answering all purposes. Consequently the confusion which would unavoidably arise if a culture solution of several salts containing the necessary elements of plant food were introduced is avoided by the employment of seedlings.

Lupine seedlings were transferred directly from the sphagnum, in which they had germinated twenty-four to forty-eight hours previously, to the solution in which the experiment was to be made. In this stage of growth the seed leaves are still closely appressed one to another, and are pale yellow in color. The initial root is 3 to 6 cm. long, and shows as yet no indication of the appearance of lateral branches. Care was taken to keep the moss so wet as to preclude a normal development of root hairs; and in this respect the result would be the same if the radicles had been immersed in water immediately after germination. It was desired to render as slight as possible the change of conditions in transferring from one medium to the other. There is every reason to believe that under these circumstances the amount of injury sustained by the plants as a result of the change of substratum was reduced to a minimum.[1]

[1] Wolf demonstrated [Landwirthsch. Versuchsst., 6, 203, (1864)] that plants which had been grown in soil until a considerable root system was developed and then shifted to an aqueous solution (as in the experiments of De Saussure and others) could not be depended upon to give as satisfactory results as plants which had been cultivated from the moment of germination in aqueous solutions. But in the case of seedlings transferred from loose wet sphagnum to water before any lateral roots had appeared no difficulty of this sort need be apprehended.

From the experiments of others with plants cultivated in salt solutions it would appear that *Lupinus albus* agrees pretty closely in point of sensitiveness with other large-seeded Leguminosæ, e. g., peas (*Pisum sativum*), beans (*Phaseolus vulgaris*), and, at least in some cases, with the horse bean (*Vicia faba*).[1]

In order to determine how closely plants of the same family correspond in their resistance to toxic effect, and at the same time to obtain data as to the behavior of a plant whose economic importance in arid regions is inestimable, a number of experiments were made with alfalfa (*Medicago sativa*). Here we have to deal with a plant whose seeds are many times smaller than those of the white lupine (1.5 to 3 mm. in greatest diameter). The radicle of the alfalfa seedling is correspondingly small and delicate, and hence requires more careful manipulation than does that of Lupinus. Alfalfa seeds were germinated in wet blotting paper, and were transferred to the solutions when the radicles were 1 to 2 cm. long.

A basis for comparison of the effects of toxic solutions upon plants of very different character and relationship is afforded by Heald's investigations of the action of extremely dilute solutions of hydrochloric acid upon seedling peas, pumpkins, and maize.[2] This author calculates that while one part of hydrogen ions (liberated by dissociation) in 6,400,000 parts of water killed the root tips of the pea (*Pisum sativum*),[3] one part in 3,200,000 was required to produce a similar effect upon the pumpkin (*Cucurbita pepo*) and one part in only 1,600,000 to destroy the root tips of maize (*Zea mays*). In other words, maize offers four times and the pumpkin twice as much resistance to the toxic effect of hydrochloric acid as do peas and lupines.

These results emphasize the importance of extending the present investigations to other plants of as widely different botanical relationship as possible. It is also of great moment that experiments be made with different stages of growth of the same plant, from the germinating seed to some point near maturity. It is as certain that the same kind of plant at various periods of development differs in its reaction to a given salt solution as that the reaction of the same plant to the same solution will be affected by variations of temperature and, perhaps, of illumination.[4]

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[1] But not always, for True [Annals of Botany, 9, 372, (1895)] found the white lupine "more strongly affected by a 0.25 per cent solution than is *Vicia faba* by one of 1 per cent KNO_3 content." He finds Pisum likewise more sensitive than *Vicia faba*.

[2] Bot. Gazette, 22, 136 (1898).

[3] The white lupine appears to be about equally sensitive to H-ions, for Kahlenberg and True [Bot. Gazette, 22, 91 (1896)] determined its limit of endurance in a solution of HCl to be $\frac{1}{44000}$ normal, while later Kahlenberg and Austin [Journ. Physical Chem., 4, 557 (1900)] fixed upon $\frac{1}{45000}$ normal as a more accurate limit.

[4] Storp [Landwirthsch-Versuchsst., 13, 76 (1884)] found zinc sulphate to be extremely injurious to germinating seedlings when exposed to the light, but harmless, or nearly so, in the dark.

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The practical value of such a development of these studies is indicated by certain conditions to which agriculture in alkali regions is subject. It is well known that while at the beginning of the season the salt components are often pretty equally distributed through a considerable depth of soil and are in consequence comparatively harmless, the increased evaporation which accompanies increased temperatures and decreased atmospheric moisture as the season advances draws these salts to the surface of the soil, where they often effloresce and form "crusts" (especially in the case of sodium carbonate and sodium sulphate). Hence older plants are frequently exposed to the action of much more concentrated solutions than the same individuals when younger had to contend with. Furthermore, the accidents of irrigation may materially alter the alkali content of a soil in the midst of the growing season of a crop. It is therefore to be hoped that this important extension of the investigation may soon receive attention.

DETAILS OF MANIPULATION.

The manner of preparing the solutions and the plants to be cultivated has already been described. A few words about methods and details followed in the experiments are in order.

To contain the solutions, glass vials nearly 3 cm. in diameter and holding about 70 c. c. of liquid were used. In the experiments with lupines, only one plant was suspended in each vial by means of a hole bored through a close-fitting thin cork stopper, the aperture being entirely closed by means of cotton batting. Protection against undue evaporation from the upper portion of the plant was secured by placing several vials in a glass jar containing a little water and inverting another jar over the whole. The plant was so adjusted in the cork that 1 to 3 cm. of the terminal portion of the radicle was immersed in the solution, the uppermost portion of the radicle extending through the vapor-saturated space between solution and stopper, while the hypocotylary section was invested with moist cotton.

In the case of alfalfa five or six plants were inserted in each vial in the following manner: A piece of aluminum wire was passed through the cork stopper in such a way as to allow it to be raised or lowered at discretion. On the portion of the wire included in the vial five or six small loops were made of proper size to hold in place each a seedling plant, with its seed leaves resting on the loop and its root immersed in the solution.

The duration of the culture in the salt solution was generally limited to twenty-four hours, as it was usually possible at the end of that period to determine accurately whether the root tip had been killed or not. Frequently, however, the plants were returned to the solution for a second period of equal duration in order to remove all doubt upon this point.[1] If at the end of that period no growth had taken

[1] In this particular, as in others, the experimental methods outlined by Kahlenberg and True [Bot. Gazette, 22, 87, 90 (1896)] have been followed, as it was desirable to make as close comparison as possible with their results.

place since the first examination, it was regarded as reasonably certain that the root tips had perished, and a less concentrated solution was tried. To obviate the possibility of mistaking a temporary condition of plasmolysis for final loss of vitality the roots were in earlier experiments transferred, after twenty-four hours, from the salt solution to distilled water; but this precaution soon proved to be needless. In all the experiments a control culture in distilled water was maintained under conditions of temperature and illumination identical with those of the salt cultures. As a matter of course, the growth of the roots is by no means as rapid in distilled water as in ordinary river water or in a prepared culture solution.

It was sought to keep the external conditions as nearly as possible uniform during the entire series of experiments and a temperature of 19° to 21° C. was maintained in the laboratory.[1]

The rate of growth during the period of experiment was ascertained by marking the radicle with india ink just before placing it in the solution. The mark, which was made as fine as was compatible with permanency, was placed at a distance of 15 mm. from the root tip in the case of the lupines and 10 mm. in the case of alfalfa (*Medicago*) so as safely to include the entire zone of active growth in the primary root.[2] This method of measuring the growth of roots was employed by Sachs in his classical studies upon the growth of primary and lateral roots,[3] and has been widely adopted by plant physiologists.[4] By comparison of the marked root with a ruled surface the amount of growth during any given period can be determined with all the accuracy necessary in experiments of the kind here described.[5]

By using a considerable number of individual plants in each experiment with each solution (usually five in case of Lupinus and ten or twelve in case of Medicago) it is believed that the variant due to individual differences in vigor has been practically eliminated.[6]

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[1] In this connection Klemm [Jahrb. f. wiss. Botanik, **28**, 659 (1895)] calls attention to the great variability exhibited by plants as to their limit of endurance in solutions of acids of definite concentration if other external conditions be varied. Askenasy [Ber. deutsch. bot. Gesellsch., **8**, 61 (1890)] describes the effect upon the growth of roots produced by different temperatures or by a variation of temperature during a limited period of time.

[2] Sachs determined the length of the growing portion, in the case of roots of other Leguminosæ, to be 8 to 10 mm. for *Vicia faba* and 3.5 to 6.5 mm. in *Pisum sativum*. [Arb. d. bot. Inst. Würzburg, 1, 413 to 419 (1873); Gesammelte Abhandl., 2, 803 (1893)]

[3] Gesammelte Abhandl., 2, 778.

[4] For example, Kahlenberg and True use this method in all their experiments with plants in solutions of toxic substances. [See Bot. Gazette, **22**, 88 (1896)]

[5] Askenasy [Ber. d. deutsch. bot. Gesellsch., **8**, 64, (1890)] shows that this method of marking causes a retardation of growth during the first hour thereafter, but that this is overcome after two hours. Consequently the method could be used without hesitation in these experiments, although it is sometimes attended by disadvantages when the phenomena of growth itself are studied.

[6] More than 2,500 seedlings of *Lupinus albus* and 700 of *Medicago sativa* were employed in the whole series of experiments.

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Indeed, that this was the case was pretty effectually shown by several repetitions of the experiments with most of the solutions. It is also indicated by the general regularity with which toxic effect is shown to increase with every increase in concentration of the solution of each salt. By several times repeating experiments with solutions of approximately the critical strength the above-mentioned source of error due to fluctuations in temperature, etc., was likewise reduced to a minimum.

DETERMINATION OF THE LIMIT OF ENDURANCE.

In ascertaining the degree of concentration of a given salt solution which will just permit the root tips to retain their vitality during the period of experiment, one must of course be able to determine also the point at which death definitely occurs. The death point is evidently to be sought far below the degree of concentration which permits no elongation whatever to occur during the period of experiment, for often radicles, of which the marked zone had increased in length several millimeters (even 6) at some time during the experiment, were indubitably dead at the end of twenty-four hours.[1] The mere fact of elongation, irrespective of the time in which it has taken place, does not therefore determine the concentration of a salt solution in which roots will survive, although sometimes useful in ascertaining whether the root is absolutely dead at the end of a given period. It is to the general condition of the apical portion of the root that we must look for a criterion. While it is sometimes difficult to describe those symptoms which denote the death of the root tip, it is comparatively easy to recognize them after one has acquired sufficient experience with the behavior of plants grown in toxic solutions.

One of the most easily detected of the phenomena accompanying death in plants is final loss of turgor due to excessive plasmolysis. In other words, the tissues lose their water, and are unable to make good the loss, even when restored to normal conditions. This is due primarily to a change in the osmotic equilibrium of the plant cells. Ordinarily, through the controlling activity of the protoplasm, a sufficient osmotic pressure is maintained in the sap cavity of the cell to

[1] Experiments were made with solutions of a strength known to be fatal, yet permitting some elongation during twenty-four hours. Sodium sulphate (0.05 normal), sodium carbonate (0.02 normal), and magnesium chloride (0.05 normal) were selected, and in every case it was found that elongation ceased entirely after three to five hours. In a water control, on the other hand, growth was still progressing at the end of six hours, and an examination at the end of twenty-four hours showed that it had been pretty equally distributed throughout the entire period. These results as to toxic action correspond with Sachs's statement [Landwirthsch. Versuchsst., 1, 219 (1859)]; Gesammelte Abhandl., 1, 430 (1892)] that "roots appear to lose more and more the power of absorbing water containing salt the longer they are in contact with it."

retain the necessary minimum of water. But through various influences, such as exposure of the tissues to a salt solution whose concentration exceeds a certain limit, this power of adjustment may be temporarily lost. In such cases a considerable proportion of the cell water diosmoses through the ectoplasm, and the protoplast in consequence shrinks away from the cell walls, to which it is normally closely applied. If the unfavorable condition persists, this temporary plasmolysis may become permanent, and the cell is killed outright.

Such disorganization due to extreme plasmolysis can usually be detected immediately by an examination of the plant tissues with the microscope, and is one of the best indications of death.[1] Roughly, however, injury of this nature is sufficiently indicated after a certain lapse of time by loss of rigidity and elasticity in the plant or part of a plant affected; in other words, it becomes flaccid. If, for example, a root thus rendered flaccid by culture in a salt solution fails to regain its turgor after being transferred to water or to a nutritive solution, it may safely be considered as injured beyond recovery. This was found to be the most satisfactory test of death employed.[2]

The color of the tissues is often a useful symptom of destructive changes. Thus all the sodium salts employed, when given in suffi-

[1] "The only externally perceptible change [indicating death] is in many cases collapse, a more or less strong, irregular recession of the protoplast from the cell wall, which does not, however, accompany by any means all reactions of substances which occasion death." [Klemm, Desorganisations-erscheinungen der Zelle. Jahrb. für wiss. Botanik, 28, p. 657 (1895).]

[2] Sachs [Arb. bot. Inst. Würzburg, 1, 386; Gesammelte Abhandl., 2, 774] mentions as an indication of the approaching death of the root tip the disorganization of the cells of the root cap, which becomes mucilaginous. This was noted in many cases, but was not found to be a practical test of complete loss of vitality. Another indication of injury to the apical portion of the root is a sharp bend near the tip, which is very different from the normal gentle curvatures. This usually appears where loss of turgor from plasmolysis is not manifested. While indicating injury, this symptom by no means necessarily implies complete loss of vitality and, therefore, does not serve our purpose as a symptom of death. Solutions of a certain concentration of magnesium sulphate, magnesium chloride, and calcium bicarbonate were found to produce this phenomenon in a marked degree. In the case of the salt last mentioned the roots continued to grow slowly in distilled water, during a second period of twenty-four hours. True [Ann. of Botany, 9, 377, (1895)] alludes to these "sharp curves characteristic of injury."

Another means of detecting loss of vitality in protoplasm, to which, however, recourse was not had in the progress of this work, is its coloration when dead by means of nigrosin, which does not color and does not injure living protoplasm. See Pfeffer [Ueber Aufnahme von Anilinfarben in lebende Zellen. Unters. aus d. bot. Inst. Tübingen, 2, 268, 269], who found in experiments with roots of duckweed (Lemna) and with Spirogyra that nigrosin is not absorbed by cells while alive. Living root hairs exposed for three days to a 0.5 per cent solution of this stain assumed no coloration whatever, while hairs after death when similarly treated readily absorbed it.

cient amount, decolorized the tissues of the apical portion of the root. This lost its normal brilliant white appearance[1] and assumed a lurid-whitish color. In the case of sodium carbonate (Na_2CO_3) and of sodium bicarbonate ($NaHCO_3$) there occurred a marked clearing of the tissues similar to that produced by the hydrates of potassium and sodium, the root tips becoming nearly transparent. This change is completed long before any loss of turgor is apparent. Magnesium salts (chloride and sulphate) discolored the surface of the roots, producing brownish spots which gradually spread over the whole surface.[2] The difference in character of physiological effect produced by salts of the same acid in the case of sodium on the one hand, and of magnesium on the other, is very great when gauged by these external appearances.

Another effect produced by some of these salts is an irregular enlargement of a portion of the root. This is very marked in the case of calcium chloride, in a solution of 0.3 normal or thereabouts. The root just above the tip develops a fusiform swelling of which the greatest transverse diameter (2 to 3 mm.) lies 5 to 10 mm. from the apex of the root. A less marked formation of this sort is sometimes produced by magnesium chloride, and even by other salts.[3]

It is well to emphasize once more the fact that the death of the tip of the primary root, and not that of the plant as a whole or even of the entire root, was taken in these experiments as the indicator of the toxic action of solutions. The condition of the distal 10 to 20 mm.

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[1] The "shining white opaque appearance which is characteristic of all healthy roots and which is due to air contained in the intercellular spaces." (Sachs, Landwirthsch. Versuchsst., 1, 216; Gesammelte Abhandl., 1, 427).

[2] Mettenius [quoted by Wolf in Landw. Versuchsst., 7, 202, (1865)] found that these spots, which appear on the roots of both the bean and maize when placed in solutions of magnesium salts, are due to a coagulation of the contents of the epidermal cells, which he did not, however, further describe. Wolf remarks that they do not appear upon plant roots in magnesium salt solutions if a salt of potassium, ammonium, or calcium be present.

[3] Sachs (Arb. bot. Inst. Würzburg, 1, 411, 412; Gesammelte Abhandl., 2, 800) describes swellings of apparently similar character which developed upon roots grown in moist air and watered at long intervals. Wolf [Landw. Versuchsst., 6, 218 (1864)] found that a concentrated solution of potassium sulphate acted in the same manner. "The root tips soon swell in the solution; the form of the root finally resembles that of the root of a tuber-bearing plant. Such swellings arise in particular abundance where lateral roots will break through." The action of a one-fourth per cent solution of potassium nitrate upon roots of *Lupinus albus* as described by True [Ann. of Botany, 9, 374 (1895)] is exactly similar to that of calcium chloride. "Swellings appeared near the tips and the ends tapered suddenly to sharp points. On the other hand, the growth in thickness was much greater than normal, the radicles above the swellings reaching the size of large radicles of *Vicia faba* of the same length."

only was necessarily involved.[1] In the more dilute solutions which are still considered toxic, because destroying the root tip, the proximal portion of the root and the upper part of the plant are often not conspicuously injured by twenty-four or forty-eight hours' exposure. After a certain lapse of time lateral roots are sometimes put forth and grow vigorously in a solution (especially of calcium chloride) which had killed the apical portion of the primary root.

This power of gradual accommodation on the part of the plant to a solution which at first checked its growth and even destroyed the sensitive tissues of the root tip has often been remarked. It is but a step from this to the well-known fact that by gradually increasing the strength of a salt solution in which plants are cultivated they can be made to endure a degree of concentration which would soon be fatal if administered directly.[2] It follows that the limits of endurance here recorded for *Lupinus albus* are merely those of its root tip, selected as being the most sensitive indicator, and are in some cases lower than the limits which would denote death of the plant as a whole. Furthermore, the limit of endurance for the entire plant could undoubtedly be still further elevated by gradually increasing the strength of solution in which the plants are cultivated.

But our present investigation aims merely at a comparison of the relative toxicity of the various "alkali" salts, to attain which the simplest and readiest means are to be preferred. A standard for further comparisons, rather than a thorough investigation of the problem in all its ramifications, is the end of the present paper.

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[1] This was likewise the objective of the experiments of Kahlenberg and True [Bot. Gazette, **22**, 88, (1896)]. In order to obtain results closely comparable with theirs, especially as bearing upon the hypothesis of electrolytic dissociation, their mode of procedure has been closely followed in this as in other details. In advocacy of this method of determining toxic action, Professor True writes: "Repeated experiments for years have convinced me that the method used gives the most delicate and easily managed test that I know of for bulky objects like Lupinus roots."

Coupin [Rev. Gén. de Botanique, **10**, 177 (1898)] criticises the work of Kahlenberg and True, previously quoted, to the effect that it is impossible to accurately determine the toxic limit of a solution in the short period of experiment (twenty-four hours) allowed by those authors. However, as Professor True observes, it was not the point at which the whole plant succumbs, but that which marks the death of the zone of growth in the primary root, which formed the objective of his experiments. Coupin's method was to grow his plants for several days in the solutions to be tested, taking the strongest solution in which the plant as a whole continued to grow after the first few hours as marking the limit of endurance ("équivalent toxique"). It is obvious, therefore, that no direct comparison is possible between the results obtained by Coupin on the one hand and by Kahlenberg and True, as well as those here recorded, on the other, Coupin's limits of endurance being necessarily much higher.

[2] Thus Stange [Bot. Zeitung, **50**, 292 (1892)] found that root tips of *Lupinus albus* and *Phaseolus vulgaris* soon died if exposed directly to a 0.5 per cent solution of potassium nitrate, but by gradually increasing the concentration they could be made to endure nearly 1 per cent without death of the protoplasm.

RESULTS WITH PURE SOLUTIONS.

CONCENTRATION MAXIMUM PERMITTING SURVIVAL OF THE ROOTS.

By applying the methods and tests outlined above it was possible to determine with a reasonable degree of accuracy the limit of concentration for each of the salts in pure solution in which the root tips of young seedlings of white lupine could just survive. It is believed that, like conditions being maintained and the same plant in the same stage of development being used, the limits will not be materially altered by further experiment. Moreover, it is regarded as not improbable that the salts will be found toxic in about the order stated below if other plants or other stages of growth of the same plant be tested with them. The limit of endurance in a solution of each particular salt will doubtless be higher or lower for different objects, but the general sequence of harmfulness should remain practically unaltered, so far as the higher plants are concerned. Experience alone can demonstrate the correctness of this assumption.

The limit of concentration permitting roots of white lupine to retain their vitality during twenty-four hours is, for each of the more important readily soluble "alkali" salts, as follows, the limit being stated both in parts of salt per 100,000 of solution and in fractions of a normal solution:

TABLE I.—*Results of experiments with pure solutions.*

Name of salt.	Degree of concentration.	
	Parts per 100,000 of solution.	Fractions of a normal solution.
Magnesium sulphate	7	0.00125
Magnesium chloride (1)	12	.0025
Sodium carbonate	26	.005
Sodium sulphate (2)	53	.0075
Sodium chloride (3)	116	.02
Sodium bicarbonate (4)	167	.02
Calcium chloride	1,377	.25

NOTES.—(1) With magnesium chloride the limit of endurance (for the whole plant), as determined by Coupin [Rév. Gén. de Bot., 10, 188 (1898)], is 0.8 per cent, while with magnesium sulphate the limit is 1 per cent, thus reversing the order of toxicity for the two salts as given above. Wolfe (Landw. Versuchsst., 6, p. 214) notes the strongly toxic effect of magnesium solutions upon roots of bean and maize. The brown coloration of the surface of the radicle, induced by these salts, appeared a few hours after immersion. Wolf's suggestion that the very poisonous effect of magnesium sulphate may be due to the decomposition of the salt by excretions of the roots can not be regarded as possessing great probability. His experiments, which were designed primarily to ascertain the volume of water absorbed by the plant from solutions of various salts of different concentration, are considered by him to indicate that the cell wall [ectoplasm] is less permeable to sulphates than to other salts (l. c., p. 217). Loew (Bul. No. 18, Div. Veg. Phys. and Path., p. 42) found that Spirogyra died after four or five days of immersion in a 0.1 per cent solution of magnesium sulphate, but remained alive for a long period in equivalent solutions of sulphates of potassium, sodium, and calcium. Similarly a 1 per cent solution of magnesium nitrate killed a smaller Spirogyra in six to twelve hours, while the nitrates of potassium, sodium, and calcium, in solutions of corresponding strength, did not destroy the plant. The peculiarly poisonous action of salts of magnesium described by Loew is explained by him on the hypothesis that calcium forms intimate compounds with proteids, and that these are essential to the organization and life of the cell-nuclei and chloroplasts of the higher plants. Consequently, if magnesium is supplied without calcium to plants, especially in the form of readily soluble salts, such as chloride, nitrate, and sulphate, the acids of the magnesium salts would be attracted by the calcium which formed part of the nuclear proteid compounds. The latter would consequently be disorganized, magnesium being unable to take the place of calcium in proteid compounds without fatal disturbances of equilibrium in the cell. As evidence for this hypothesis is adduced the corrective effect of the addition of lime to either soils or culture solutions in which plants are suffering from magnesium poisoning, and the further fact that plants suffer less in culture solutions from which both calcium and magnesium are absent than in such as contain magnesium but no calcium. It must be observed, however, that the chemical rationale of this theory

rests upon the assumption that calcium is a stronger base than magnesium, and will exert a greater attractive force upon acids, while it ignores the application of the mass law to the distribution of an acid between two bases, which itself accounts very satisfactorily for the facts observed.

(2) Of sodium sulphate Wolf (Landw. Versuchsst., 6, pp. 210, 213) indicates that solutions of more than 0.05 per cent are toxic to roots of the bean (*Phaseolus vulgaris*). Loeb [Am. Journ. Physiology, 3, 398 (1900)], found sodium sulphate to be more poisonous than sodium chloride to eggs of a fish (*Fundulus heteroclitus*). This he attributes to a precipitation of calcium from its loose proteid compounds in the protoplasm, a reaction effected through the sulphions dissociated by sodium sulphate.

(3) The minimum toxic concentration for sodium chloride, the same plant and the same methods being used, is placed about three times as high (one-sixteenth normal) by True [Amer. Journ. Sci., ser. 4, 9, 187 (1901)]. As the experiments with sodium chloride here described were repeated several times, without variation in the result, no explanation for this discrepancy is apparent.

Many experiments have been made with sodium chloride as to its effects upon plants. It may be of interest to refer to some of those in which limits of endurance have been determined, especially as these are in all cases much higher than that given above for root tips of *Lupinus albus*. Storp [Biedermann's Centralbl., 13, 76 (1884)] found that sodium chloride in a solution of greater concentration than 0.01 per cent retarded the germination of seeds. Eschenhagen [Ueber den Einfluss von Lösungen verschiedener Concentrationen auf den Wachsthum der Schimmelpilze (1889)], quoted by Stange in Bot. Zeitung (1892, p. 255), gives the following limits for the active growth of fungi in solutions of sodium chloride and of sodium nitrate:

Fungus.	Per cent sodium chloride.	Per cent sodium nitrate.
Aspergillus	17	21
Penicillium	15	21
Botrytis	12	16

Richter [Ueber die Anpassung der Süsswasseralgen an Kochsalzlösungen Flora, 75, 4 (1892)] found that *Zygnema stellinum genuinum* lived two months in a 6 per cent solution of sodium chloride added to a culture solution, and more than a year when the sodium chloride solution was 2 per cent or weaker. De Freitag [Archiv für Hygiene, 11, 68 (1890)] is authority for the statement that *Bacillus tuberculosis* lived three months, and the typhus Bacillus six months in a saturated solution of sodium chloride. Coupin [Révue Gén. de Botanique, 10, 177 (1898)] obtained the following limits for various plants in solutions of sodium chloride:

Plant.	Per cent limit of endurance.	Per cent in different solution.
Wheat	1.8	0.5
Peas	1.2	.25
White lupine	1.2	.....
Maize	1.4	.....
Vetch	1.1	.....

According to W. Sigmund [Landw. Versuchsst., 47, 1 (1896)] the maximum concentration of NaCl solutions endurable by germinating seeds of cereals is 0.5 per cent, of legumes 0.3 per cent, of rape 0.1 per cent. Loew [Bul. 18, Div. Veg. Phys. and Path., p. 19] found that Spirogyra suffers in a solution containing 0.5 per cent of sodium chloride.

(4) Carbonic acid (HCO_3) is here regarded as a monovalent acid, so that a gram molecule (instead of one-half of a gram molecule) to the liter has been used in making up normal solutions of sodium bicarbonate. To prevent inversion to the normal carbonate (Na_2CO_3) [see Cameron and Briggs, Bul. 18, Div. of Soils, 1900; also Jour. Physical Chem., 5, 537 (1901)] solutions of the bicarbonate were always well charged with carbon dioxide and were tested for hydroxyl with phenolphthaleine before being used in culture experiments, and again at the end of the experiment. It is quite possible, of course, that a small error was thus introduced, as the carbonic acid formed by the dilution of carbon dioxide in water may have retarded somewhat the dissociation or ionization of the sodium hydrogen carbonate. It is improbable that sodium hydrogen carbonate, unaccompanied by the normal carbonate, would ever occur in nature except in the presence of an excess of carbon dioxide, which fact is a further justification of the procedure here described.

In order to demonstrate that this excess of carbon dioxide was not in itself injurious to the roots of white lupine, the following simple check experiment was made: Carbon dioxide was forced into distilled water until a saturated solution was obtained. Plants were then entered in this solution, which was protected as completely from loss of carbon dioxide as circumstances would permit. After twenty-four hours the solution was tested with barium hydrate, and the heaviness of the resulting precipitate of barium carbonate showed that very much more carbon dioxide still remained than is present in ordinary water. During this period the roots grew nearly as well as in water containing only the normal quantity of carbon dioxide. It might be supposed that a solution of carbon dioxide in water and presumably containing the hypothetical carbonic acid must needs be itself quite toxic, as it would be expected to yield the hydrogen ion which recent investigations have shown to be excessively toxic. In this connection some work of Pfeiffer [Ann. Chem. (2), 23, 625 (1884)] will prove interesting. This investigation showed that a solution of carbon dioxide is an exceedingly poor conductor; that in fact the highest conductivity observed in such solutions was only about a thousandth of that which Kohlrausch's work showed it should possess. See also Knox [Ann. Phys. Chem., 54, 44 (1895)] and Walker and Cormack [Journ. Chem. Soc., 77, 5 (1900)].

It would seem rational, therefore, to consider that carbonic acid does not exist itself, or at least in only minute quantities in solutions of carbon dioxide, but is *potentially* present in its constituents and only forms in the presence of some added influence, such as a base. And that, therefore, even a concentrated aqueous solution of carbon dioxide would contain no hydrogen ions, or so very small a quantity as to be ineffective against so delicate an indicator as a plant root.

Experiments to ascertain the limit of endurance in pure solutions were also made with seedlings of alfalfa (*Medicago sativa*). Although absolute limits for this plant have not, as yet, been determined, they appear to be somewhat lower for every salt than in the case of *Lupinus albus*, but more than one-half as high. Thus for magnesium sulphate the limit appears to lie between 0.000625 and 0.00125 normal, while for magnesium chloride the limit will be found between 0.00125 and 0.0025 normal.

A glance at the preceding table shows very clearly that it is the basic rather than the acid radicle of the salts used which chiefly determines their relative toxicity. In other words, the cathions derived from these salts are very much more active in their effect upon plant tissues than are the anions. This is strikingly brought out by a comparison among themselves of the three chlorides of magnesium, sodium, and calcium, on the one hand, and of the chlorides and sulphates of magnesium and sodium, respectively, on the other. In the former case, although the anions (Cl) are identical in kind we find magnesium chloride eight times as toxic as sodium chloride, and one hundred times as toxic as calcium chloride. In the latter case, magnesium sulphate is only twice as toxic as magnesium chloride, while sodium sulphate is little more than two and one-half times as injurious as the corresponding chloride.

The results with salts of magnesium, as compared with those of sodium, confirm the results obtained by W. Wolf, Loew, and others as to the strongly poisonous qualities of the former base.

All four of the salts of sodium with which experiments were made are widely distributed and often very abundant in the alkali regions of the western United States. As was to be expected, sodium carbonate or black alkali was found to be the most harmful of these, but it is not much more injurious than sodium sulphate. That the latter is much more poisonous than sodium chloride is a result not altogether anticipated at the beginning of the investigation.[1] As was predicted, sodium bicarbonate proved to be somewhat less toxic than sodium chloride.[2]

As a matter of fact, the limit of endurance in a solution of sodium bicarbonate is not much higher in parts of salt per 100,000 of water

[1] Stewart [Ninth Ann. Rep. Utah Agr. Exp. Sta. p. 26 (1898)] found sodium chloride more injurious than sodium sulphate to germinating seeds of legumes and cereals.

[2] Very different results from these here recorded as to the relative toxicity of the carbonate and bicarbonate of sodium were obtained by Coupin [Rév. Gén. de Botanique, 12, 180 (1900)]. Experimenting with seedlings of wheat, this author found that the least concentrated fatal solution ("équivalent toxique") is 1.1 grams per 100 of water for sodium carbonate, while for the bicarbonate it is 0.6 gram. Hence the latter would be twice instead of one-fourth as poisonous as the former. Sigmund [Landw. Versuchsst., 47, 2 (1896)] found that while Na_2CO_3 at a concentration of 0.5 per cent killed germinating seedlings of vetch and rape and retarded the development of wheat seedlings, $NaHCO_3$ at the same concentration was harmless.

and is no higher in fractions of the reacting weight than it is for sodium chloride. It should be mentioned, however, that the plants survive in a solution of the bicarbonate of the strength given in the table in much better condition than in the corresponding concentration of the chloride, so that the latter must be regarded as the more harmful of the two salts. The wide distribution of sodium bicarbonate and its abundance as a component of many alkali soils renders the demonstration of its marked poisonous effects upon vegetation, even when present in comparatively dilute solutions, a matter of no little importance. Although much less injurious than is the normal carbonate or "black alkali," the presence of this salt can not be neglected in future estimations of the value of western soils.

An explanation of the harmful action of sodium bicarbonate which at first suggested itself was that by its dissociation free hydrogen ions are liberated, though the weight of evidence on chemical grounds is rather against this view.[1] It has been shown by recent investigators[2] that it is probably the hydrogen ions dissociated by certain acids (especially the strong mineral acids) which make them so injurious to organisms, even in extremely dilute solutions. If this were the reason for the toxicity of sodium bicarbonate it would follow that water heavily charged with carbon dioxide, as in the check experiment described above (p. 20), would prove similarly injurious to plant roots by reason of the dissociation of hydrogen ions by the carbonic acid (HCO_3), which is supposed to be formed when carbon dioxide is dissolved in water. But, as has already been noted, no toxic effect was obtained with an aqueous solution of carbon dioxide.[3]

[1] Walker and Cormack, Journ. Chem. Soc., 47, 5 (1900) and Bodländer, Zeit. für physik. Chem., 35, 25 (1900).

[2] Kahlenberg and True, Bot. Gazette, 22, 87 (1896); Heald, l. c., p. 134; Loeb, Pflüger's Archiv f. die gesammte Physiologie, 69, 4 to 9 (1898); Kahlenberg and Austin, Journ. of Physical Chem., 4, 553 (1900); True, Amer. Journ. Sci. ser. 4, 9, 183 (1900).

[3] There exists among plant physiologists some diversity of opinion as to the direct effect of large quantities of carbon dioxide upon the growth of roots. The subject is evidently one which needs a more thoroughgoing investigation, not only from a scientific standpoint, but from economic reasons also, as it is intimately connected with tillage and drainage problems. For an extended discussion of this question see Lopriore in Jahrb. für wiss. Botanik, 28, 531 (1895). The author mentions that Boehm found roots of the bean (*Phaseolus vulgaris*), when exposed to an excess of carbon dioxide, to be shorter, and the lateral roots fewer, than is ordinarily the case. Jentys [Bul. Internat. Acad. Sci. Cracovie, 1892, 306 (1893)], found that by passing atmospheric air to which had been added 4 to 12 per cent of carbon dioxide through the soil of culture pots, an injurious effect upon the roots of the bean and the yellow lupine could be detected, although the injury was less than in Boehm's experiments. On the other hand, wheat was practically unharmed. Lopriore (l. c., p. 623), concludes that carbon dioxide in excess has a hindering but not a permanently injurious influence upon the functions of protoplasm. This effect is not ascribable to the absence of oxygen, but is specific. Plant cells can gradually accommodate themselves to a quantity of carbon dioxide, which, if applied directly, would injure them. Lopriore's experiments were made chiefly with Mucor, yeast, and pollen grains and tubes.

As there is probably but a small difference in the amount of sodium ions yielded by sodium chloride and by sodium hydrogen carbonate, at the dilutions here involved, the difference in their toxicity observed must in all probability be ascribed mainly to the anions.

It is likely that the great toxicity of normal sodium carbonate is largely due to the hydroxyl ions resulting from the hydrolysis of this salt. In the case of the bicarbonate of sodium in all the experiments involving its use, and described in this paper, hydrolysis was avoided by dissolving carbon dioxide in the solution in amounts sufficient to prevent any inversion to the normal carbonate, a reaction which would necessarily result were hydrolysis of the bicarbonate permitted.[1] Since it seems reasonably certain that HCO_3 ions are not toxic, the toxic influence of the sodium bicarbonate solutions could be safely attributed to the sodium ion alone were it not for the fact that toxic solutions of this salt produce the peculiar "clearing" effect upon plant tissues which is well known in the case of the normal carbonate of sodium and of the hydrates of potassium and of sodium. This effect is very different from that caused by other salts of sodium, e. g., the sulphate and the chloride.

Calcium chloride was found to be ten times less injurious than is sodium chloride. For this reason, and because it rarely predominates in areas of any considerable size, this salt can not be regarded as, under ordinary circumstances, a dangerous component of alkali soils. As we shall presently see, there is reason to believe that it can in many cases be a highly beneficial component of the soil.

Attention should be directed to the fact that the figures given in the above table represent only approximate results, the determination of the absolute limit for each salt depending theoretically upon the testing of an almost infinite number of concentrations. Thus, as a rule, solutions of a concentration of 0.2, 0.15, 0.1, 0.075, 0.050, etc., normal were employed, although more numerous intermediate concentrations, e. g., of 0.2000, 0.1825, 0.1750, etc., normal could have been tested. However, it is doubtful whether the reaction upon plant tissues of finer differences could be detected, and it is believed that for all practical purposes a sufficient number of concentrations was used. As has already been noted, the limits of endurance in the case of different salts are not of precisely equal value, the roots not surviving in all in exactly the same condition. Thus roots which survived after twenty-four hours in a 0.005 normal solution of sodium carbonate presented a perfect appearance and grew vigorously in distilled water during a subsequent period of twenty-four hours. On the other hand, roots which endured a 0.25 normal solution of calcium chloride presented a markedly abnormal aspect at the end of twenty-four hours, and made little subsequent growth when transferred to water. Likewise

[1] See paper on Equilibrium between Normal Carbonates and Bicarbonates in Aqueous Solutions, Cameron and Briggs. Bul. 18, Div. Soils, U. S. Department of Agriculture (1901); Jour. Physical Chem., 5, 537 (1901).

roots survived in better condition in 0.0075 normal sodium sulphate than in 0.02 normal sodium chloride solution. It was found much easier to determine sharply the limit of endurance for sodium carbonate and sodium bicarbonate than for other salts, as in 0.005 and 0.02 normal solutions of the two carbonates, respectively, all, or nearly all, roots survived in apparently perfect condition, while in 0.0075 and 0.025 normal, respectively, all roots were killed and symptoms of advanced disorganization were apparent after twenty-four hours.

CONCENTRATION MINIMUM PROHIBITING ELONGATION OF ROOTS.

A comparison of the seven salts above enumerated in regard to the degree of concentration of each in which absolutely no elongation of the roots occurred during twenty-four hours is interesting, as illustrating how far this point is removed from that of the minimum concentration which is still toxic. It will be seen that the position of the salts in this scale does not at all correspond with their sequence in the table of limits of endurance. In many cases, especially when the solution was still more concentrated, not only no increase of length but a positive shrinkage of 0.5 to 2 mm.[1] was detected.

TABLE II.—*Concentrations which absolutely prevent growth.*

Name of salt.	Concentration of solution.	
	Parts per 100,000 of solution.	Normal.
Sodium carbonate	280	0.05
Sodium bicarbonate	417	.05
Magnesium chloride	960	.2
Sodium chloride *a*	1,160	.2
Sodium sulphate	1,410	.2
Calcium chloride	1,652	.3
Magnesium sulphate	1,680	.3

a According to Pfeffer (Pflanzenphysiologie, Ed. 2, 1, 414) a culture solution to which enough potassium nitrate or sodium chloride is added to render it isosmotic with a 2 per cent potassium nitrate or 1.7 per cent sodium chloride solution causes a cessation of growth in ordinary plants while an increase to 3 per cent is necessary to prevent growth in halophytes.

It is impossible to reconcile this sequence, as compared with that of Table I, with the notion, which still appears to find advocates, that the injurious effect of these salt solutions is merely a function of their osmotic pressures. If any fresh evidence were needed to disprove this assumption it is afforded by the fact, very clearly brought out in the present investigations, that marked toxic effects frequently appear long before loss of turgor has manifested itself or cessation of growth has occurred. It is certain that no useful conclusions as to the degree of toxicity of a solution can be drawn from its osmotic pressure.

True [Bot. Gazette, **26**, 407 (1898)] calls attention to the difficulty of distinguishing the purely chemical from the merely osmotic (plasmo-

[1] In some solutions this loss of length due to plasmolysis was as great as that found by Sachs in roots which were exposed for thirty minutes to the dry air of a room. (Arb. bot. Inst. Würzburg, **1**, 396; Gesammelte Abhandl., **2**, 784, 785.)

lyzing) effect of a salt solution. He experimented with Spirogyra in order to obtain means of making such distinction, comparing its behavior in a solution of cane sugar, which is believed to possess no chemically toxic properties, with that in solutions of sodium chloride and potassium nitrate. The maximum concentration of the sugar solution in which life could be maintained was determined to be 0.75 normal. Allowing for differences of dissociation, 0.46 normal should then be the maximum endurable concentration of a sodium chloride solution if only its osmotic pressure were involved. In fact, however, 0.1 normal was found to be the actual limit, so that a definite toxic action of sodium chloride must be admitted (loc., cit., p. 410).[1]

Were the injurious action of these solutions attributable to plasmolysis alone, an approximately equal amount of elongation should take place in solutions of different salts, if each solution contain an equal fraction of a gram equivalent to a given amount of water, granting that the dissociation of each salt was equally great at the given concentration, as would be approximately true for strong electrolytes at the concentrations here used; for elongation and growth in general are intimately connected with the turgor conditions of the tissues,[2] which, in turn, depend upon the osmotic force exerted by the surrounding solution. That force being equal for each of two solutions, the turgor and the amount of elongation of the roots immersed in each should also be equal if osmosis were the only factor involved. That this is not the case is sufficiently established by the figures given in Table II.

RESULTS WITH LESS SOLUBLE SALTS.

Besides the easily soluble alkali salts a few others were used in experiments, i. e., calcium sulphate [$CaSO_4$] calcium carbonate [$CaCO_3$], calcium bicarbonate [$Ca(HCO_3)_2$], and the carbonate and bicarbonate of magnesium [$MgCO_3$ and $Mg(HCO_3)_2$]. These were found to be either toxic in a very slight degree, indifferent, or positively stimulating to growth.

[1] From True's results it is clear that at the concentrations involved in our experiments with pure solutions the toxic effect observed must in every case be referred to action of a chemical rather than a purely physical nature. In some of the mixed solutions, such as the very concentrated ones containing calcium sulphate, it may be that their osmotic pressure determines the limit of endurance of the plant roots.

[2] For example that, except perhaps in rare instances, growth can not be resumed after an interruption (such as is occasioned by transference of plants from one medium to another) unless the turgor of the plant or the organ concerned is nearly or quite normal, was shown by Curtis [Bul. Torr. Bot. Club, 27, 1 (1900)] in the case of mycelia of Mucor, Botrytis, and Penicillium, grown in a plasmolyzing solution (4 per cent potassium nitrate). As this author expresses it, "there is a necessity of a certain turgor force before growth is possible, and growth can not occur until a turgor pressure has been reached which is normal to the plant growing in the given solution." (Loc. cit., p. 11.)

In a (necessarily dilute) solution of gypsum, which contained a considerable quantity of the undissolved salt in suspension, the plants grew decidedly more vigorously than in pure water.[1]

In a saturated, but necessarily very dilute, solution of normal calcium carbonate [$CaCO_3$], roots of Lupinus elongated nearly twice as much and remained in decidedly better condition during twenty-four hours than in distilled water. This solution gave a faint reaction for hydroxyl (with phenolphthaleine) at the beginning of the experiment, but none at the end of twenty-four hours, doubtless because of the production of carbonic acid through the excretion of carbon dioxide by the roots. But a solution of calcium bicarbonate [$Ca(HCO_3)_2$], made by saturating a portion of the same calcium carbonate solution with carbon dioxide, permitted only about one-third as much growth of the roots as took place in distilled water. Their condition was decidedly abnormal at the end of twenty-four hours, even the turgor being poor.[2]

Magnesium carbonate [$MgCO_3$], in a solution which gave a strong hydroxyl reaction with phenolphthaleine, allowed the roots to grow about as rapidly as in distilled water and to remain in about normal condition. On the other hand, a portion of the same solution to which an excess of carbon dioxide was added and in which no free hydroxyl could be detected (either before or after the experiment) exerted a strongly toxic action upon the roots. These made practically no growth during twenty-four hours; their turgor became decidedly inferior, and there occurred a marked discoloration of brownish spots, such as is produced by the readily soluble magnesium salts. Here it is obviously a case of a greater amount of magnesium in solution, owing to the presence of carbon dioxide in

[1] The stimulating effect which lime often exercises upon the growth of plants is too well known to require illustration. The presence of calcium salts in considerable quantity leads to a more vigorous production of root hairs than is normally the case, as can easily be demonstrated by culture experiments, in which only the tip of the root is immersed in the calcium salt solution. On the surface of the root above the solution a great number of unusually long root hairs appear. To this effect of the presence of lime, and the consequent readier absorption of potassium and ammonium salts from the soil, Loew attributes in part the benefits obtained by liming. (Bul. No. 18, Div. Veg. Phys. and Path., U. S. Department of Agriculture, p. 43.) That calcium salts directly stimulate growth, apart from the production of root hairs, is, however, shown by cultures with the root entirely immersed in an aqueous solution, thus precluding any important development of these organs.

[2] Schloesing's investigations [Comptes rendus, 74, 1552 (1872)] showed that 100,000 parts of pure water, i. e., free from dissolved carbon dioxide, would dissolve about 1.3 parts of calcium carbonate. Treadwell and Reuter [Zeit. für anorg. Chem., 35, 28 (1900)] showed that by increasing the pressure of the carbon dioxide in the gas phase in contact with the solution until it was one atmosphere, the solubility was increased so that 100,000 parts of water would dissolve 116 parts of calcium carbonate. Even at this extreme solubility there would be but 46 parts of calcium per 100,000 of water, as against about 60 parts in a saturated solution of calcium sulphate, in which plants thrive well.

excess.[1] Why the corresponding calcium solution should also hinder growth can not be satisfactorily explained at present.

RESULTS WITH MIXED SOLUTIONS.

Upon comparing the limits of endurance for lupine roots in pure solutions of the "alkali" salts with the limits determined by the methods employed in a field survey, it became obvious that the former were vastly lower than the latter; and that furthermore the order of toxicity of the several salts as fixed by investigators in the field differed greatly from that obtained by experiments in the laboratory. This was strikingly the case with magnesium sulphate, which is decidedly the most toxic of the seven salts when alone in a pure aqueous solution, but which is regarded as the least injurious by students of alkali soils. But it was recalled that none of these salts usually occurs in any notable quantity in the soil save in the presence of one or several others, both of the readily soluble salts and of the comparatively insoluble magnesium carbonate, calcium carbonate, and calcium sulphate. The key to the discrepancy appeared therefore to lie in mixtures of the various salts, and the study of these became, logically, the next step in the investigation.

In experimenting with mixed solutions it was planned to test every possible combination of two of the readily soluble salts with which experiments were made in pure solutions. Another line of experiments, from which were obtained results which are believed to be of considerable scientific interest and from an economic point of view to indicate one of the possible solutions of the alkali soil problem, consisted in combining each of the readily soluble salts with each of three difficultly soluble ones—calcium sulphate, calcium carbonate, and magnesium carbonate. The only triple mixtures so far tried are those of each readily soluble salt (except calcium chloride) with calcium sulphate and calcium carbonate. Sodium bicarbonate was tested only in this triple mixture.

Although the work with mixtures of salts is by no means com-

[1] Treadwell and Reuter [Zeit. für anorg. Chem., 17, 199 (1898)] showed that at 15° C. and under a partial pressure of carbon dioxide in the vapor phase equal to zero, pure water dissolves about 63 parts of magnesium carbonate per 100,000. With a partial pressure of carbon dioxide in the vapor phase equal to one atmosphere there was dissolved about 1,211 parts magnesium hydrogen carbonate, equivalent to 698 parts of the normal carbonate per 100,000 of solution. It is thus seen that the solubility is enormously increased by the presence of carbon dioxide. Cameron and Briggs [Bul. 18, p. 22, Division of Soils, U. S. Department of Agriculture (1900)] showed that a solution of magnesium carbonate in solution in equilibrium with ordinary air contained about 18 parts of magnesium in 100,000 of solution, which might have been expected to be enough to prohibit growth in view of the toxicity of solutions of magnesium chloride and magnesium sulphate. It should be further noted that it was shown that 6 parts of the dissolved magnesium was combined as the normal carbonate, so that the solution contained more than appreciable amounts of OH ions, resulting from the hydrolysis of this latter salt.

pleted, the data thus far obtained throw so much light on the whole subject of alkali soils, and go so far to account for the fact that the limits of endurance of plants in pure solutions of the various salts are low as compared with those determined from the observations of survey parties in the field, that it seems advisable to present them here.

In the case of mixtures of two readily soluble salts, solutions of each, of twice the desired concentration, were mixed in equal volumes. Where one of the salts is a comparatively insoluble one, it was added in solid form to a solution of definite concentration of the soluble one, and the mixture was then diluted to the required concentration, as though the more soluble salt alone were present. (The source of error incurred by this method was considered so slight as to be practically negligible.) The mixture was then allowed to stand for a week or ten days with frequent shaking, in order to bring it to equilibrium before using. In all mixtures of magnesium carbonate and of calcium carbonate alone with other salts, the undissolved residue was removed by filtration. Likewise in earlier experiments with calcium sulphate added to other salts, the residue was removed, but in those upon which are based the limits given in the tables it was retained. In all cases where both calcium sulphate and calcium carbonate were added, the undissolved residue remained during the culture. The difference in limit due to the presence or absence of a solid excess was, however, usually imperceptible, and always slight.

In every case the object was to ascertain how far the limit of endurance for the roots in the presence of the more toxic salt could be raised by addition of one that is less injurious. Although the concentration of solution of the latter is invariably stated, if it be a readily soluble salt, it is the concentration of solution of the more poisonous salt as denoting a corresponding limit of endurance to which attention is chiefly directed. It is interesting that in cases where both of the salts mixed are readily soluble ones the less toxic salt appears usually to be more effective in neutralizing the more toxic one when added in concentration somewhat above rather than below that in which plant roots will endure it when alone. Thus, in a mixture containing equal volumes of 0.0075 normal sodium carbonate and 0.01 normal sodium sulphate, roots of two plants survived, but all died when the mixture contained 0.0075 normal sodium carbonate and only 0.005 normal sodium sulphate. Also a majority of the roots could retain their vitality in a mixture containing equal volumes of 0.0025 normal magnesium sulphate and of 0.01 normal sodium sulphate, but not in 0.0025 normal magnesium sulphate plus 0.005 normal sodium sulphate. Similar results were obtained by adding sodium sulphate to magnesium chloride and sodium chloride to magnesium sulphate. The reverse was true, however, in the mixtures of magnesium chloride and sodium chloride, the less concentrated solution of the latter proving more beneficial.

The concentrations are stated, as in preceding tables, both in parts of salt to 100,000 of solution and in fractions of a normal solution.

In the following tables of the effects of mixtures each of the more soluble alkali salts (excepting sodium bicarbonate) is taken up in succession in the order of its toxicity in pure solution. The neutralizing effect is expressed in terms of the greatest concentration of the more toxic salt endurable in the presence of the less toxic one. As the determination of the value of a less injurious salt in neutralizing a more toxic one was the objective of all experiments with mixtures, it follows that the number of added salts decreases successively from table to table. For comparison, the limit of endurance for the more toxic salt in pure solution is stated at the head of the table. The details of neutralizing effect upon each salt are taken up in connection with its respective table, while a discussion of the general significance of the whole series of experiments with mixtures of two solutions is appended.

The results embodied in Tables III to IX were obtained from experiments with *Lupinus albus* only. In Table X, however, the limits are given for both *Lupinus albus* and *Medicago sativa* (alfalfa) in solutions of each readily soluble salt (excepting calcium chloride) in the presence of an excess of calcium sulphate and calcium carbonate together.

MAGNESIUM SULPHATE IN MIXTURES.

The following table shows the results of experiments with Lupinus in solutions of magnesium sulphate with other salts added:

TABLE III.—*Limits for magnesium sulphate in mixtures.*

Name of salt added.	Greatest endurable concentration of magnesium sulphate.		Concentration of the salts added.	
	In fractions of a normal solution.	In parts per 100,000 of solution.	In fractions of a normal solution.	In parts per 100,000 of solution.
None	0.00125	7		
Magnesium chloride	.000625	3.5	0.0025	12
Sodium carbonate	.00125	7	.0025	13
Sodium sulphate	.00375	21	.01	80
Sodium chloride	.0075	42	.015	87
Calcium chloride	.2	1,120	.2	1,101
Magnesium carbonate	.01	56	Saturated.	Saturated.
Calcium carbonate	.02	112	Saturated.	Saturated.
Calcium sulphate	.6	3,360	Saturated.	Saturated.
Calcium sulphate and calcium carbonate	.4	2,240	Saturated.	Saturated.

In the light of figures given above, the enormous discrepancy between the results obtained by experiments with this salt in pure solution and the limit determined by field survey is completely obliterated. For in alkali lands magnesium sulphate is rarely, if ever, found in any quantity except in the presence of calcium sulphate; and it is commonly accompanied by both sodium and calcium sulphate (the Billings,

Mont., type of alkali soil[1]). Addition of sodium sulphate, which is itself so injurious in a pure solution, raises the limit for magnesium sulphate three times, while the presence of calcium sulphate allows a small proportion of the roots to barely survive during twenty-four hours in a solution of magnesium sulphate 480 times as concentrated as that which, in pure solution, represents the limit of endurance. A careful comparison was made between 0.3 and 0.4 normal solutions of magnesium sulphate, both in the absence and the presence of an excess of calcium sulphate, five individuals of *Lupinus albus* being cultivated for 48 hours in each of the four solutions. The following table gives the results:

TABLE IV.—*Magnesium sulphate with and without calcium sulphate.*

Solutions.	Average elongation of the marked portion of the root.	General condition of the roots.
	Millimeters.	
Magnesium sulphate (0.3 normal)	0.7	Extremely flaccid, and discolored with brownish blotches; extremely plasmolyzed.
Magnesium sulphate (0.3 normal) + calcium sulphate.	10.2	Turgor normal; plasmolysis none; but all roots quite badly discolored.
Magnesium sulphate (0.4 normal)	.3	About as in 0.3 normal.
Magnesium sulphate (0.4 normal) + calcium sulphate.	13.0	Turgor normal; plasmolysis none; all but one root quite badly discolored.

In both pure solutions the protoplasm of the nearly isodiametric cells of the periblem was completely withdrawn from the cell wall and collected with the nucleus in a compact mass near the center of the cell; while in both solutions to which calcium sulphate had been added no trace of plasmolyzing action could be detected in the cells of the periblem, the protoplasm being closely applied to the wall, with large vacuoles in the older cells, and the nucleus usually peripheral. Precautions were taken while preparing the sections to keep the tissues immersed in the culture solution, and the absence of plasmolysis in the roots taken from the solutions containing calcium sulphate is sufficient evidence that the pure solutions had produced this effect during the period of culture rather than after withdrawal.[2]

[1] See Whitney and Means, Bul. 14, Div. Soils, U. S. Department of Agriculture (1898), and Cameron, Bul. 17, p. 32, Div. Soils, U. S. Department of Agriculture (1901).

[2] Wolf's observation (see footnote, p. 40) that both $Ca(NO_3)_2$ and $Mg(NO_3)_2$ are readily absorbed by plant roots when mixed together, while neither is readily absorbed from a pure solution, renders it highly probable that in this case of a mixture of $MgSO_4$ and $CaSO_4$ it is the rapid endosmosis of the salts into the cells of the plant roots which prevents plasmolysis of the latter. In short this mixture is to be compared with those substances described by Overton [Vierteljahrsschr. Naturf. Gessells ch. Zürich 40, 1 (1895)] which produce only transient plasmolysis, owing to their more or less rapid passage through the ectoplasm into the cell sap. As determined by De Vries [Jahrb. für wiss. Botanik, 14, 537 (1884)], a 1.8 per cent solution of magnesium sulphate (which would correspond to our 0.3 normal

In the presence of both calcium sulphate and calcium carbonate added in excess to a solution of magnesium sulphate, the limit of endurance is only two-thirds as high as when calcium sulphate alone is added.

Calcium as the chloride has also a powerful effect in neutralizing the toxicity of magnesium sulphate. But here the addition of a new anion (Cl), besides the added cathion (Ca), seems to diminish the beneficial effect of the latter, since the chloride, although a readily soluble salt, raises the limit for magnesium sulphate only one-third as much as does the little-soluble calcium sulphate. In a mixture of calcium chloride and magnesium sulphate a crystalline precipitate of calcium sulphate separates slowly or rapidly in proportion to the concentration of the solutions, so that the case becomes that of the contact of solid calcium sulphate with a solution of magnesium chloride. As would be expected, the limit of endurance for magnesium sulphate plus calcium chloride is the same as that for magnesium chloride plus calcium sulphate (Table V).

Sodium salts are very much less effective in neutralizing magnesium sulphate than are salts of calcium. In the case of sodium salts it is the chloride which is most effective, so that here we seem to have a beneficial effect of the anion as well as of the cathion. Yet the absence of any neutralizing effect when magnesium chloride is added to magnesium sulphate shows that the Cl ions alone are ineffective.

In one case the addition of a salt with a common basic ion—i. e., magnesium carbonate—raises the limit of endurance in magnesium sulphate eight times.[1] By a simple process of elimination, since magnesium ions are ineffective in the form of magnesium chloride when added to magnesium sulphate, although chlorine ions appear to have in themselves some neutralizing value when added as sodium chloride, we are compelled to attribute the beneficial influence of magnesium carbonate to CO_3, or more probably HCO_3, ions, a point to which we will return in discussing the stimulating effect of dilute solutions of sodium carbonate and sodium bicarbonate. Noteworthy is the fact that calcium carbonate, although much less soluble than the corresponding salt of magnesium, is twice as effective an antidote for magnesium sulphate. This affords another striking proof of the great efficacy of calcium as a remedy for magnesium poisoning.

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solution), is the isotonic equivalent of a 0.1 normal solution of potassium nitrate, which is usually taken as the unit in measurements of osmotic pressure of solutions. True [Bot. Gazette, 26, p. 410 (1896)] found that plasmolysis of Spirogyral cells in a KNO_3 solution first appeared at a concentration of 0.25 normal. De Vries' results seem to indicate that the osmotic value of each component in a mixed solution (of two or three salts) is equal to that of the respective component when present alone at the given concentration, a point not in accord with well-established facts.

[1] The roots barely survive in poor condition in a 0.01 normal magnesium sulphate solution plus an excess of magnesium carbonate; but in 0.005 normal magnesium sulphate solution plus magnesium carbonate some of the roots were perfectly normal after a twenty-four hours' culture.

MAGNESIUM CHLORIDE IN MIXTURES.

The results of experiments with magnesium chloride in mixtures with other salts are shown in the following table:

TABLE V.—*Limits for magnesium chloride in mixtures.*

Name of salt added.	Greatest endurable concentration of magnesium chloride.		Concentration of the salts added.	
	In fractions of a normal solution.	In parts per 100,000 of solution.	In fractions of a normal solution.	In parts per 100,000 of solution.
None	0.0025	12		
Sodium carbonate	.0025	12	0.00375	19.5
Sodium sulphate	.01	48	.01	80
Sodium chloride	.01	48	.02	116
Calcium chloride	.1	480	.15	726
Magnesium carbonate	.0025	12	Saturated.	Saturated.
Calcium carbonate	.04	192	Saturated.	Saturated.
Calcium sulphate	.2	960	Saturated.	Saturated.
Calcium sulphate and calcium carbonate	.2	960	Saturated.	Saturated.

In the alkali soils of the Western United States magnesium chloride rarely occurs in such large quantities as to be regarded as more than secondary in importance.[1]

As in the case of magnesium sulphate, calcium is found to be much more effective than sodium in neutralizing magnesium, but here calcium chloride is relatively more effective than with magnesium sulphate, raising the limit for magnesium chloride one-half (instead of only one-third) as far as does calcium sulphate. But calcium is much less effective with the chloride than with the sulphate of magnesium, as is evident from the relative efficacy of calcium sulphate in raising the limits of endurance of the two magnesium salts. Hence we have here another indication (as in the case of calcium chloride added to magnesium sulphate) that chlorine ions by their presence lower the neutralizing efficacy of calcium; although in the absence of the latter base, magnesium chloride is only one-half as toxic as is magnesium sulphate. While the beneficial effect of calcium sulphate upon magnesium sulphate is decreased by the addition of an excess of calcium carbonate, the presence of the carbonate does not affect the value of calcium sulphate as an antidote to magnesium chloride.

While calcium carbonate is equally effective in raising the limits of the two soluble magnesium salts (sixteen times), magnesium carbonate, which raised the limit of magnesium sulphate eight times,

[1] Magnesium rarely makes its specific effects upon plant life felt in the "alkali" soils, owing to the omnipresence there of considerable calcium salts. In certain areas of the Eastern States, notably in the so-called "serpentine barrens" of Pennsylvania and Maryland, it appears to be relatively more important, probably because it is there present in excess over calcium, although the actual amount of both, which may be present in the soil solutions at any given time, must be extremely small.

has no effect upon magnesium chloride. As it appears to be necessary to regard the HCO_3 ions as the effective element in the former combination, we must conclude that these act beneficially in the presence of Mg and SO_4, but are powerless in the presence of Mg and Cl. But as calcium carbonate is equally effective as an antidote to magnesium chloride and to magnesium sulphate, it would follow that the power of Cl ions to hinder the effect of HCO_3 ions disappears in the presence of Ca ions, while, as already noted, Cl ions appear to diminish the value of Ca ions as an agency for counteracting Mg ions. Comparisons such as these show how difficult it is to attempt an interpretation of toxicological phenomena in the light of current chemical and physiological ideas. Possibly determinations of the solubility and degree of dissociation of these different salts in mixtures may afford some clue to the numerous anomalies. On the other hand, it is difficult to see any justification for using the reactions of organisms in determining the dissociation constants of electrolytes. The many nonconcordant results recently described in the literature can hardly be regarded as throwing discredit upon the dissociation hypothesis, but rather as demonstrating the unsatisfactory nature of the method employed for the investigation in hand.

Sodium sulphate and sodium chloride are equally effective in raising the limit of magnesium chloride (four times). The former is more effective, and the latter decidedly less so, than in the case of magnesium sulphate, so that the anions (Cl, SO_4) and not alone the cathions (Mg, Na) appear to make their influence felt in these cases.

SODIUM CARBONATE IN MIXTURES.

Table VI shows results of experiments with mixtures of other salts with sodium carbonate:

TABLE VI.—*Limits for sodium carbonate in mixtures.*

Name of salt added.	Greatest endurable concentration of sodium carbonate.		Concentration of the salts added.	
	In fractions of a normal solution.	In parts per 100,000 solution.	In fractions of a normal solution.	In parts per 100,000 of solution.
None	0.005	26		
Sodium sulphate	.0075	39	0.01	80
Sodium chloride	.0025	13	.01	58
Calcium chloride	.25	1,300	.25	1,377
Magnesium carbonate	.01	52	Saturated.	Saturated.
Calcium carbonate	.0075	39	Saturated.	Saturated.
Calcium sulphate	.03	156	Saturated.	Saturated.
Calcium sulphate and calcium carbonate	.03	156	Saturated.	Saturated.

As the above table shows, sodium chloride is ineffective as an antidote to sodium carbonate; calcium carbonate barely raises the limit

of endurance, while magnesium carbonate merely doubles it. It is interesting that magnesium carbonate should here be more effective than the corresponding salt of calcium, since in all other cases the latter is the more beneficial.[1] Sodium sulphate is likewise of very little neutralizing value, and the soluble salts of magnesium possess none so far as was ascertained. Calcium sulphate raises the limit only six times, the presence or absence of an excess of calcium carbonate not affecting the value of the sulphate. This comparatively slight efficacy of calcium sulphate in neutralizing "black alkali" is rather surprising in view of the accepted ideas of students of alkali soils in regard to the curative value of gypsum.[2] The comparative inefficacy of calcium sulphate in this case contrasts strikingly with its power to neutralize sodium in the forms of sulphate (Table VII) and chloride (Table VIII).

Calcium chloride is the only salt found to be very effective in neutralizing sodium carbonate, raising the limit of endurance for the latter fifty times. A mixture of solutions of the two salts causes an immediate heavy precipitate of calcium carbonate, to which fact the efficacy of the added salt must be largely ascribed. We should be dealing in this case with a solution of sodium chloride containing a large excess of calcium carbonate. Yet by direct addition of solid calcium carbonate to a solution of sodium chloride, the limit of endurance for the latter can be raised only three times, i. e., to 0.06 normal (see Table VIII). Here again chemistry appears to be powerless to afford an explanation of a phenomenon which, in the present state of our knowledge, must be regarded as paradoxical.[3]

A very noteworthy result was obtained by experiments with sodium carbonate, as well as with sodium bicarbonate, in the presence of an excess of calcium sulphate and calcium carbonate. In solutions of critical concentration of both of these mixtures a majority of the roots of the lupine plants were completely destroyed with pronounced

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[1] The probability of the formation of a double carbonate, with a consequent lowering of the active mass, as well as a probable change of nature of the ions, suggests itself very forcibly in this connection. It is hoped that time and opportunity will be found in the near future to test this supposition in the laboratory.

[2] Hilgard, Bul. 128, Agr. Exp. Sta., Univ. Calif., pp. 16 to 18 (1900). It should be stated, however, that Hilgard recommends the application of gypsum under physical conditions which would not probably be considered analogous to those under which the experiments here described were performed.

[3] In marked contrast with this anomalous case is that of the mixture of magnesium sulphate and calcium chloride, in which a precipitate of calcium sulphate is formed and which is therefore to be regarded as a solution of magnesium chloride containing a solid excess of calcium sulphate. Here the limit of endurance is the same as when solid calcium sulphate is added directly to a solution of magnesium chloride. The same thing is true of a mixture of sodium sulphate and calcium chloride in which the limit of endurance is the same as for sodium chloride plus calcium sulphate.

corrosion due presumably to the action of hydroxyl ions, while a smaller number survived in apparently perfect condition, and this occurred in repeated experiments. In critical solutions of other salts and mixtures of salts, however, there was rarely such sharp difference in appearance between roots which survived and those which died during twenty-four hours' culture; as a rule none of the roots were in normal condition at the end of the experiment. In other words, the difference of individual plants in their power to resist toxic action appears to be more pronounced in the case of the two carbonates of sodium than of other "alkali salts." This would indicate that the selection of plants for resistance to "black alkali" offers a simpler problem than where resistance to other components of alkali soils is to be sought.

SODIUM SULPHATE IN MIXTURES.

Experiments with sodium sulphate in mixtures with other salts show the following results:

TABLE VII.—*Limits for sodium sulphate in mixtures.*

Name of salt added.	Greatest endurable concentration of sodium sulphate.		Concentration of the salts added.	
	In fractions of a normal solution.	In parts per 100,000 of solution.	In fractions of a normal solution.	In parts per 100,000 of solution.
None	0.0075	53		
Sodium chloride	.00675	26.5	0.01	58
Calcium chloride	.2	1,272	.2	1,102
Magnesium carbonate	.03	212	Saturated.	Saturated.
Calcium carbonate	.04	281	Saturated.	Saturated.
Calcium sulphate	.5	3,530	Saturated.	Saturated.
Calcium sulphate and calcium carbonate [a]	.3	1,908	Saturated.	Saturated.

[a] See Bul. 17., p. 22 et seq., Division of Soils, U. S. Department of Agriculture, 1901.

Sodium sulphate is very abundant in "alkali" soils, often occurring in contact with each or several of the other salts. In the Billings, Mont., type, for example, it is accompanied by the sulphates of magnesium and calcium, while in the Fresno, Cal., type it is in contact with sodium carbonate.

Most effective for neutralizing this salt is calcium sulphate, which raises the limit more than sixty times when added alone. In the presence of an excess of calcium carbonate, however, calcium sulphate can increase the limit of endurance for sodium sulphate only about forty times. This is probably due to a forcing back of the dissociation and decrease of solubility of the calcium sulphate by the calcium carbonate, although, as Cameron and Seidell[1] have shown, either salt is rather soluble in dilute solutions of sodium sulphate.

[1] Solution Studies of Salts Occurring in Alkali Soils, Bul. 18, Division of Soils, U. S. Department of Agriculture.

As in the case of all the other salts except sodium carbonate, calcium chloride is less effective than calcium sulphate, raising the limit only twenty-seven times. In this case, as in the mixture of calcium chloride with magnesium sulphate, a crystalline precipitate of calcium sulphate is formed, so that it actually becomes a case of the contact of calcium sulphate with a solution of sodium chloride, and the same limit was obtained by a direct test of this latter mixture. Calcium carbonate is much less effective in neutralizing sodium sulphate than in counteracting the toxic action of magnesium salts.

Calcium sulphate is more effective as an antidote to sodium sulphate than to any other salt tried except magnesium sulphate. In both these cases the anion of the added salt is the same as that of the more toxic one; hence the cathions alone seem to operate. Possibly a double salt of sodium and calcium is formed in this mixture. Since calcium sulphate is much less efficacious in neutralizing the chlorides of magnesium and sodium than the corresponding sulphates, while it is generally more beneficial than is calcium chloride, it seems almost certain that the beneficial action of Ca ions is in some way hindered by the presence of Cl ions. That Cl ions are in themselves less toxic than are SO_4 ions would appear from the fact that the chlorides of magnesium and of sodium are less injurious in pure solution than are the corresponding sulphates.

SODIUM CHLORIDE IN MIXTURES.

Experiments with sodium chloride in mixtures with other salts yielded the results shown in the following table:

TABLE VIII.—*Limits for sodium chloride in mixtures.*

Name of salt added.	Greatest endurable concentration of sodium chloride.		Concentration of the salts added.	
	In fractions of a normal solution.	In parts per 100,000 of solution.	In fractions of a normal solution.	In parts per 100,000 of solution.
None	0.02	116		
Calcium chloride	.2	1,160	0.2	1,101
Magnesium carbonate	.04	232	Saturated.	Saturated.
Calcium carbonate	.06	348	Saturated.	Saturated.
Calcium sulphate	.2	1,160	Saturated.	Saturated.
Calcium sulphate and calcium carbonate	.2	1,160	Saturated.	Saturated.

Sodium chloride is probably the most widely distributed and generally abundant of the soluble components of alkali soils, occurring practically wherever the land is notably impregnated with these noxious salts.[1] As the above table shows, calcium sulphate and calcium chloride are equally effective in neutralizing the toxicity of sodium chloride, although in the case of sodium sulphate and the

[1] A notable exception is the Billings area in Montana.

soluble salts of magnesium, the former is decidedly more beneficial than the latter.

As in the case of magnesium chloride, the presence of calcium carbonate does not affect the neutralizing value of calcium sulphate, although decidedly diminishing it in the case of magnesium sulphate and sodium sulphate. It has been shown by Cameron and Seidell[1] that an excess of solid calcium carbonate has but a very slight effect on the solubility of calcium sulphate in sodium chloride solutions at the concentrations here involved. And from the general resemblance between the phenomena presented by calcium sulphate in contact with sodium chloride and magnesium chloride solutions, it is probable that calcium carbonate would have a like effect in the latter cases. It is to be regretted that laboratory investigations of the solubility of solid calcium carbonate and calcium sulphate in contact with solutions of soluble sulphates have not yet been made.

CALCIUM CHLORIDE IN MIXTURES.

In the experiments with calcium chloride in mixtures with other salts the following results were obtained:

TABLE IX.—*Limits for calcium chloride in mixtures.*

Name of salt added.	Greatest endurable concentration of calcium chloride.		Concentration of the salts added.	
	In fractions of a normal solution.	In parts per 100,000 of solution.	In fractions of a normal solution.	In parts per 100,000 of solution.
None	0.25	1,377		
Magnesium carbonate	.25	1,377	Saturated.	Saturated.
Calcium carbonate	.25	1,377	Saturated.	Saturated.
Calcium sulphate	a0.3	1,652	Saturated.	Saturated.

a About.

Calcium chloride is quite generally distributed in alkali soils, being usually present in small patches wherever sodium chloride is abundant. As would be expected from the relatively very high concentration of the pure solution of this salt endured by roots of the white lupine, the limit can not be materially raised by the addition of other salts.

SODIUM BICARBONATE IN MIXTURES.

Sodium bicarbonate was tested in mixture only with calcium sulphate and calcium carbonate together, which raised its limit of endurance two and one-half times (see Table X). It usually occurs in nature in contact with the normal sodium carbonate.

CALCIUM SULPHATE AND CALCIUM CARBONATE IN MIXTURES.

In the tables of limits of endurance in mixtures, as in those of pure solutions, the figures do not perfectly state the case. For example,

[1] Bul. 18, Division of Soils, U. S. Department of Agriculture (1901).

As in the case of all the other salts except sodium carbonate, calcium chloride is less effective than calcium sulphate, raising the limit only twenty-seven times. In this case, as in the mixture of calcium chloride with magnesium sulphate, a crystalline precipitate of calcium sulphate is formed, so that it actually becomes a case of the contact of calcium sulphate with a solution of sodium chloride, and the same limit was obtained by a direct test of this latter mixture. Calcium carbonate is much less effective in neutralizing sodium sulphate than in counteracting the toxic action of magnesium salts.

Calcium sulphate is more effective as an antidote to sodium sulphate than to any other salt tried except magnesium sulphate. In both these cases the anion of the added salt is the same as that of the more toxic one; hence the cathions alone seem to operate. Possibly a double salt of sodium and calcium is formed in this mixture. Since calcium sulphate is much less efficacious in neutralizing the chlorides of magnesium and sodium than the corresponding sulphates, while it is generally more beneficial than is calcium chloride, it seems almost certain that the beneficial action of Ca ions is in some way hindered by the presence of Cl ions. That Cl ions are in themselves less toxic than are SO_4 ions would appear from the fact that the chlorides of magnesium and of sodium are less injurious in pure solution than are the corresponding sulphates.

SODIUM CHLORIDE IN MIXTURES.

Experiments with sodium chloride in mixtures with other salts yielded the results shown in the following table:

TABLE VIII.—*Limits for sodium chloride in mixtures.*

Name of salt added.	Greatest endurable concentration of sodium chloride.		Concentration of the salts added.	
	In fractions of a normal solution.	In parts per 100,000 of solution.	In fractions of a normal solution.	In parts per 100,000 of solution.
None	0.02	116		
Calcium chloride	.2	1,160	0.2	1,101
Magnesium carbonate	.04	232	Saturated.	Saturated.
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CALCIUM SULPHATE AND CALCIUM CARBONATE IN MIXTURES.

In the tables of limits of endurance in mixtures, as in those of pure solutions, the figures do not perfectly state the case. For example,

[1] Bul. 18, Division of Soils, U. S. Department of Agriculture (1901).

although the limit of endurance in sodium carbonate plus magnesium carbonate is 0.01 normal, while for sodium sulphate plus magnesium carbonate it is 0.03 normal, the proportion of individual seedlings whose roots survive in good condition is decidedly greater in the latter mixture than in the former.

None of the readily soluble salts occurs abundantly in alkali soils save in the presence of calcium sulphate or calcium carbonate, and most often in contact with both. Hence it follows that the limits of endurance for the more soluble salts in the presence of these two salts of calcium, as obtained by means of water-culture experiments, should agree closely with the limits determined by soil investigators. This proved to be the case, due allowance being made for the influence of the physical properties of a soil as compared with an aqueous solution.

The following table serves to bring together, for ready comparison, the limit of endurance for roots of both white lupine and alfalfa in solutions of six of the easily soluble salts to which a solid excess of both calcium sulphate and calcium carbonate was added, the mixtures being brought to equilibrium before using.

TABLE X.—*Results with mixtures containing two calcium salts.*

Name of salt.	Limits for lupine (Lupinus albus).		Limits for alfalfa (Medicago sativa).[a]	
	Parts per 100,000 of solution.	Normal solution.	Parts per 100,000 of solution.	Normal solution.
Magnesium sulphate	2,240	0.4	1,920	0.25
Magnesium chloride	960	.2	960	.2
Sodium carbonate	156	.03	104	.02
Sodium sulphate	2,160	.3	2,160	.3
Sodium chloride	1,160	.2	1,160	.2
Sodium bicarbonate	417	.05	667	.08

[a] In the case of alfalfa a few roots barely survive in 0.55 and in 0.3 normal magnesium sulphate, while in 0.25 normal they make a noteworthy amount of growth during forty-eight hours. In 0.2 normal sodium sulphate they make a decidedly better growth, and in 0.1 normal sodium chloride two and one-half times as much growth as in the water control.

The close correspondence between the white lupine and alfalfa in their resistance to the effects of these mixed solutions is worthy of note, especially as alfalfa appears to be more sensitive than the lupine to pure solutions. The only serious discrepancy occurs in the mixture of sodium bicarbonate, calcium sulphate, and calcium carbonate, to which alfalfa roots appear to be nearly twice as resistant as are those of white lupine.

That in the neutralizing effect upon more toxic salts which these two relatively insoluble salts exert calcium sulphate plays a much more important part than does calcium carbonate is obvious from a comparison of the limits of endurance in solutions to which either calcium sulphate or calcium carbonate alone has been added. Indeed, in the case of magnesium sulphate and of sodium sulphate the limit of endurance is decidedly lower in the presence of both calcium salts

than when calcium sulphate alone is added. On the other hand, the presence or absence of calcium carbonate appears to have no effect upon the neutralizing value of calcium sulphate when added to magnesium chloride, sodium chloride, or sodium carbonate.

An interesting comparison is that of the soluble salts, one with another, in respect to their degree of toxicity in pure solution on the one hand, and in the presence of an excess of calcium sulphate and calcium carbonate on the other. It will be observed that the sequence in the first column is very different from that in the second. The most toxic salt or mixture is placed at the head of each column.

TABLE XI.—*Order of toxicity with and without calcium salts.*

In pure solution:	In presence of an excess of $CaSO_4$ and $CaCO_3$: *a*
Magnesium sulphate.	Sodium carbonate.
Magnesium chloride.	Sodium bicarbonate.
Sodium carbonate.	Magnesium chloride.*b*
Sodium sulphate.	Sodium chloride *b*
Sodium chloride.	Calcium chloride.
Sodium bicarbonate.	Sodium sulphate.
Calcium chloride.	Magnesium sulphate.

a It has already been suggested that the limit in some of these highly concentrated solutions containing an excess of calcium salts may bear some relation to the osmotic pressure of the solution. It is therefore not a mere coincidence, perhaps, that the sequence in this column is almost identical with that in Table II (of concentrations precluding any growth during the culture).

b These two salts are equally toxic in mixtures if reacting weights be compared, while magnesium chloride is the more toxic of the two in parts of salt per 100,000 of solution.

The interest and importance of the results obtained from the experiments made with mixed solutions show the great desirability of extending further this line of investigation. In fact, no aspect of the work promises more substantial returns. An interesting problem among the many which suggest themselves in this connection is that of a possible relation between the degree of toxicity of a salt, alone or in mixture, and the readiness with which it is taken up by the plant from a solution. The occasion seems opportune to redirect attention to a series of experiments made long ago by Wilhelm Wolf[1] as to the

[1] Landw. Versuchsst., 7, 193 (1865). The studies were made with a series of solutions, each of which contained two salts in equal amount. Combinations were made with (1) salts of the same acid, but of different bases; (2) salts of the same base, but of different acids; (3) with both base and acid different. In each culture 200 c. c. of solution was employed, and after one-half of this volume had been absorbed by the plant (allowance being made for the small quantity of water evaporated directly from the solution) the amount of each salt taken up with the water was estimated by analysis of the residual 100 c. c. of solution. Young beans and maize were used in the experiments. Some of the results obtained were as follows:

From three mixtures, each containing 0.05 grams of each two salts, the plants absorbed in percentages of the original quantity of each salt supplied:

From ammonium nitrate plus calcium nitrate, 92 per cent of the former and 94 per cent of the latter.

From ammonium nitrate plus magnesium nitrate, 92 per cent of the former and 86 per cent of the latter.

From magnesium nitrate plus calcium nitrate, 74 per cent of each.

Potassium nitrate was taken up from all combinations with other nitrates

amount of each salt absorbed by a plant from a mixed solution. Especially interesting, as compared with the toxicological phenomena of pure and mixed solutions, respectively, are Wolf's results as to the effect of calcium sulphate in stimulating the absorption of other sulphates.

GENERAL SIGNIFICANCE OF RESULTS WITH MIXED SOLUTIONS.

To enter into a discussion, from the purely chemical point of view, of the widely accepted hypothesis of the dissociation of electrolytes in solution would be to exceed the proper limits of this paper.[1] It is sufficient to say that salts such as those with which we are here dealing are held to dissociate in dilute solutions, more or less com-

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(Na, NH_4, Mg, Ca) in absolutely greater amount than from a simple solution. From a solution containing 0.025 gram each of potassium nitrate and calcium nitrate the plants absorbed 100 per cent of the former and 88 per cent of the latter. From an equivalent solution of potassium nitrate plus magnesium nitrate, 100 per cent of the former and 88 per cent of the latter. The stimulation of the plant by the presence of calcium to take up greater quantities of potash is referred by Loew (l. c., p. 44) to the increased development of root hairs induced by the calcium. But if the presence of magnesium has exactly the same effect, as would appear from the experiment just quoted, we must look further for an explanation. Absorption of ammonium nitrate is decreased by the presence of other nitrates, *while that of calcium and of magnesium nitrates is stimulated thereby. It is remarkable that while neither of these last two salts is readily absorbed from a simple solution, both are easily absorbed when mixed together.*

Plants could be grown in mixtures of potassium and calcium sulphate ($K_2SO_4 + CaSO_4$) and of calcium and magnesium sulphate ($CaSO_4 + MgSO_4$), but never in mixtures of sulphates of potassium and sodium ($K_2SO_4 + Na_2SO_4$), of potassium and ammonium ($K_2SO_4 + (NH_4)_2SO_4$), nor of potassium and magnesium $K_2SO_4 + MgSO_4$), even when the solutions were very dilute.

Potassium and ammonium salts were taken up much more readily in the presence of a calcium salt than from a pure solution. This was notably the case with the sulphates, which are absorbed with difficulty from unmixed solutions. Gypsum (calcium sulphate) is absorbed in very small quantity in the presence of a potassium salt, but greatly stimulates absorption of the latter. From a mixture of calcium and magnesium sulphate little of either salt is taken up, but the presence of magnesium nitrate considerably increases the amount of calcium sulphate drawn from a solution.

From mixtures of a sulphate and a phosphate, the latter is always taken up in greater quantity. Magnesium sulphate is taken up in greater quantity in the presence of a phosphate than are other sulphates.

De Saussure's principle of the absorption of salts in solution by plant roots—i. e., that the salt is taken up in smaller proportion to the water absorbed than it occurs in the culture solution; in other words, that the residual solution becomes more concentrated—applies to the absorption of sodium chloride in the presence of a nitrate (KNO_3, NH_4NO_3, $Ca(NO_3)_2$), but does not hold as to the absorption of the nitrate itself.

[1] For the presentation of the subject in simple terms the reader is referred to a former publication by one of us. (Rep. No. 64, U. S. Department of Agriculture, p. 144, 1900.)

pletely at a given concentration according to the specific properties of the particular salt. The result is a liberation of ions—atoms or atomic groups carrying or in some way associated with an electric charge. Cathions, those furnished by the basic radicle, carry positive electricity, while anions, derived from the acid radicle of the salt, are negatively charged. Ions possess a much greater velocity[1] than do undissociated molecules, and it is now believed by many physiologists that salts owe to the properties of their ions rather than to their entire molecules the toxic and other action which they exert upon organisms.[2]

It is believed that the results of the present investigation tend to confirm this view, although it must be admitted that serious anomalies exist, to some of which attention has already been directed.

Pure solutions of the salts dealt with are shown to be generally injurious to plants, and this largely by virtue of the cathions which they yield, as a comparison of the position of the several salts in the table of toxicity in pure solutions shows conclusively. Thus magnesium salts, irrespective of the character of their anions, are much more injurious than is any sodium salt, while the three chlorides (of magnesium, sodium, and calcium) differ enormously in toxicity, regardless of the fact that they yield a common anion.

An inspection of the tables of limits in mixed solution given above makes it clear that the addition of a second, less toxic salt in most cases increases the concentration of solution of the more harmful one in which root tips can retain their vitality. It is also demonstrated that addition of a second salt of the same base, hence furnishing a different kind of anion only, is usually much less efficacious in raising the limit than is the admixture of a salt of a different base. Thus magnesium chloride is ineffective as an antidote to magnesium sulphate, sodium chloride to sodium carbonate or to sodium sulphate, and calcium carbonate to calcium chloride.

If the assumption be granted that in the dilutions here involved the magnesium salts are practically completely dissociated and that the anions do not have a toxic effect, then a 0.00125 normal solution of magnesium will be the limit when the metal is combined as the sulphate and a 0.0025 normal solution when combined as the chloride, but about a 0.002 normal solution when both chloride and sulphate are present, with two equivalents of the former to one of the latter. The same line of reasoning holds for the other cases cited, and from these facts it is evident that the anions have a part in determining the toxic effect of a

[1] That the physiological action of ions may be in some sort a function of their specific velocities is indicated by Loeb's comparison of the effects of hydrogen and hydroxyl ions, as well as of various basic cathions, upon the absorption of water by a muscle. [Pflüger's Archiv., 69, 21, (1898).]

[2] Of a rapidly growing literature on this subject the papers of Kahlenberg and True and of Kahlenberg and Austin, dealing with plants, and those of Loeb, Garrey, Anne Moore, Kahlenberg, Clark and others, treating ion action upon animals, may be cited as of great importance. (See the Bibliography, p. 56.)

salt, although a much smaller one in general than have the cathions. Furthermore, these views are in harmony with Loeb's idea that SO_4 ions are more toxic than Cl ions, because they tend to precipitate calcium from its proteid compounds.

In other cases, however, addition of a salt which furnishes new anions, but not new cathions, to the mixture is effective in raising the endurable limit of concentration for the more toxic salt. A striking case is the elevation of the limit for magnesium sulphate eight times by the addition of magnesium carbonate. Here it would appear that the HCO_3 anions alone can be the effective agency. Sodium sulphate slightly raises the limit of sodium carbonate, and a relatively unimportant increase of the concentration of a calcium chloride solution in which lupine roots can survive is obtained by addition of calcium sulphate. But in these last two cases the effect is so small as to be almost negligible, and is perhaps entirely attributable to the forcing back of the dissociation of the more toxic salt rather than to any direct physiological action of the new anions.

The superior efficacy of cathions over anions in neutralizing the toxic effect of other cathions is illustrated by the discovery that sodium is equally effective as an antidote to magnesium chloride, whether it be added as sulphate (Na_2SO_4) or as chloride (NaCl).[1] A much more striking illustration is afforded by the fact that calcium, when added to a solution of magnesium sulphate or of sodium sulphate, is very much more efficacious when furnished as the relatively insoluble sulphate than as the readily soluble chloride. In other words, the presence of chlorine anions actually hinders the full exertion of the physiological effect of calcium cathions, unless we are to believe that the superior efficacy of calcium sulphate is due merely to its greater influence in retarding the dissociation of the sulphates of magnesium and of sodium.

If we turn now to the effect of mixtures in which two kinds of cathions are present we find that these are almost invariably much less poisonous than is the pure solution of the more toxic salt. Even the addition of a sodium salt (sulphate or chloride) to one of magnesium (sulphate or chloride) raises the limit of endurance for the latter three to six times. Still more remarkable is the effect of magnesium carbonate as an antidote to salts of sodium (carbonate, sulphate, chloride), raising their limits two to four times. But these effects are trivial as compared with the extraordinary efficacy of calcium in counteracting the toxic effects of other bases (magnesium, sodium).

Even when added as the but slightly soluble carbonate, calcium raises the limit of magnesium sulphate and of magnesium chloride sixteen times, of sodium sulphate more than five times, and of sodium

[1] On the other hand, sodium chloride is twice as effective as sodium sulphate in neutralizing magnesium sulphate.

chloride three times. Calcium chloride[1] mixed with an equal volume of a magnesium or a sodium salt raises the limit of the latter as follows: Magnesium sulphate, one hundred and sixty times; magnesium chloride, forty times; sodium carbonate, fifty times;[2] sodium sulphate, twenty-seven times, and sodium chloride, ten times.

The most effective of the calcium salts tried was, however, calcium sulphate. This, when added alone in solid excess, increases the maxima of concentration endurable by the roots as follows: Magnesium sulphate, four hundred and eighty times; magnesium chloride, eighty times; sodium carbonate, six times; sodium sulphate, sixty-six times, and sodium chloride, ten times. Here we have probably the greatest effect of one kind of ion in neutralizing the effect of another kind that has yet been obtained in experiments with plants.

It is noteworthy that the effect of the calcium ions upon different salts having a common basic ion differs greatly. Thus plant roots can endure three times the concentration of a solution containing magnesium cathions and sulph-anions to which calcium sulphate is added than they can of a solution containing magnesium cathions and chlor-anions plus calcium sulphate. Yet the former solution in the absence of calcium salts is endurable in concentration only one-half as great as is the latter without a calcium salt. Here the effect may be partly due to differences of dissociation in the two solutions. But it appears necessary to attribute the greater part of it to an adverse influence, presumably exerted by chlorine ions, upon the physiological action of calcium ions in the presence of magnesium ions. Similar problems are suggested by the wide differences in the degree to which calcium sulphate can neutralize the toxic action of each of the three sodium salts.

That the phenomena exhibited by the roots of plants in their reaction to these various mixed salt solutions are not to be regarded as mere functions of chemical changes in the solution itself is patent. The problem is undoubtedly a much more intricate one, involving chemical reactions of great complexity in the protoplasm of the plant itself. In this connection it is important to call attention to the strikingly similar results obtained by Loeb[3] as to the relative toxic effect upon animals of pure and of mixed solutions.

A pure salt solution, e. g., of sodium chloride, was found to be

[1] Loew (Bul. No. 18, Div. Veg. Phys. and Path., U. S. Department of Agriculture. p. 33), referring to an experiment made by Boehm, appears to doubt the value of calcium in the form of the chloride as a plant nutrient, owing to the formation of hydrochloric acid in the assimilation of calcium by the plant. Here is another suggestion as to the reason for the inferiority of calcium chloride to calcium sulphate in neutralizing the toxic action of salts of other bases.

[2] As has already been noted (under Table VI), a heavy precipitate of calcium carbonate is formed in this mixture. so that it becomes in great part a solution of sodium chloride plus a solid excess of calcium carbonate.

[3] See the papers by this author cited in the Bibliography (p. 58).

strongly poisonous to marine animals in various stages of development—i. e., a fish (*Fundulus heteroclitus*), a jellyfish (Gonionemus sp.), and a sea urchin (Arbacia sp.). But the addition in small quantity of a salt yielding another kind of cathion, such as magnesium, potassium, and calcium, more or less neutralized this toxic effect, although each of these salts was itself toxic in pure solution. As in the case of plants, calcium was particularly effective. That it is the cathions rather than the anions added to the solution which are chiefly effective as counter agents is evident from the fact that of each base the chloride only was used. Moreover, in only one mixture of three chlorides could fertilized eggs of the sea urchin be brought to an advanced stage of development, but sodium bromide could be successfully substituted for sodium chloride in the mixture.[1] It is clear, therefore, that the anions play a very subordinate part in the physiological action of such mixtures.

Loeb suggests that the physiological effect of a pure solution, whether toxic or stimulating, is attributable to a reaction whereby various cathions which are assumed to enter into combination with the proteids of the organism are replaced by the cathion of the surrounding solution, in accordance with the law of mass. Thus, in case of an animal or organ immersed in a solution of sodium chloride, ions of calcium and of potassium would be forced from their organic compounds and sodium ions would be substituted for them. This would cause a disturbance of equilibrium and finally a cessation of irritability in the tissues. Such effect can be prevented, or, if it has not proceeded to the point of disorganization, counteracted by the addition to the solution of salts containing the corresponding cathions, i. e., potassium and calcium. Hence the author derives his conception of a "physiologically balanced salt solution," examples of which are sea water, the blood of animals, and a mixture of definite concentrations of the chlorides of potassium, sodium, and calcium. The chief function of such a solution is regarded as the maintenance of "a certain physical condition, a certain labile equilibrium, of the protoplasm or the colloids."[2]

From considerations such as these, and from the discovery that a close analogy as to absorption of water exists between the behavior of a frog's gastrocnemius immersed in a solution of a potassium, sodium, or calcium salt and that of potassium, sodium, and calcium soaps,[3] the development of Loeb's theory of the existence and function of "ion-proteid compounds" was logically inevitable. The hypothesis is stated as follows: "Salts or electrolytes in general do not exist in living tissues as such exclusively, but are partly in combination with

[1] Amer. Journ. Physiology, 3, 442 (1900).

[2] Ibid., 3, 445 (1900).

[3] See Pflüger's Archiv, 75, 303 (1899).

proteids. The salt or electrolyte molecules do not enter into this combination as a whole, but through their ions. The great importance of these ion-proteid compounds lies in the fact that by the substitution of one ion for another the physical properties of the proteid compounds change. We thus possess in these ion-proteid compounds essential constituents of living matter which can be modified at desire, and hence enable us to vary and control the life phenomena themselves. * * * If it be true that life phenomena depend upon the presence of a number of various metal proteids (Na, Ca, K, and Mg) in definite proportions, it follows that *solutions which contain only one class of metal ions must act as a poison.* The reason for this is that the one class of metal ions will gradually take the place of the other metal ions in the ion-proteids of the tissues. Even a pure NaCl solution must thus be poisonous, although this salt permeates all our tissues and is the main constituent of the [soluble] inorganic matter of the ocean."[1]

Pauli,[2] who published the same hypothesis almost simultaneously, states his views with greater positiveness. "The general distribution of the ion-proteid compound in the living organism can not be doubted; indeed, we have strong reasons for the assumption that all the proteids of the protoplasm exist there only in combination with ions." And again, "Not salts, but salt-ions, are indispensable to the organism."[3]

Loeb's experiments show that to the same ions or mixtures of ions different animals or different organs or stages of development of the same animal may react in a different manner. This was noted in the case of embryonic as compared with fully developed tissue and with myogenic as compared with nuerogenic contractions. Thus in pure solution magnesium chloride is more favorable to the development of fertilized eggs of the sea urchin than is sodium chloride, although the latter causes while the former prevents rhythmical muscular contraction. On the other hand, as the predominant salt in a triple mixture of chlorides (potassium and calcium being present in much smaller quantity), sodium chloride favors, while magnesium chloride prevents, the development of fertilized sea-urchin eggs.[4] Calcium ions prevent rhythmical muscular contraction, but allow the muscle to retain its irritability much longer than is possible in a solution from

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[1] Amer. Journ. Physiology, 3, 327 (1900).

[2] Ueber physikalisch-chemische Methode und Probleme in der Medizin, 19, Wien (1900).

[3] Loew, although attempting no such extensive generalization, has touched upon the question of ion proteids and their relation to vital phenomena in his discussion of the harmfulness to plants exhibited by magnesium salts in the absence of calcium. (See Bul. No. 18, Div. Veg. Phys. and Path., U. S. Department of Agriculture, p. 42, 1899.)

[4] Amer. Journ. Physiology, 3, 439 (1900).

which they are absent.[1] Results similar to those obtained by Loeb have recently been recorded by other investigators.[2]

That the converse case may also occur is indicated by Loeb's investigations: "Different combinations of ions may exist which all have the same effect. It seems as if the physical condition of the colloids were the essential point and that this might be affected by various ion combinations in the same way."[3]

It is not to be doubted that many peculiarities in relation to ions will likewise be discovered in plants as compared with animals. A case in point is that of magnesium chloride, which in pure solution is eight times as toxic as sodium chloride to roots of the white lupine and of alfalfa while the two salts are about equally toxic when calcium is present. Hence lupine roots react toward these two salts in a wholly different manner than do sea-urchin eggs. Furthermore, a comparison of different plants, one with another, or of different organs or stages of development in the same plant, will surely reveal numerous dissimilarities.

The importance of the ion-proteid theory as an aid to the study of the effects, both toxic and beneficial, which solutions of electrolytes induce in organisms, can hardly be overestimated. It is to be regarded as the only really scientific explanation of this class of phenomena which has yet been attempted. Incomplete as the theory is in its present form, and many as are the anomalies needing further study, we can not but welcome it as a most promising instrument wherewith to attack the vast problem of the physical properties and energies of protoplasm.[4]

Meanwhile it is highly desirable that the study of ion action upon plants be extended. Experiments should be made with a larger number of different ions, and with mixtures containing more than two kinds of cathions.[5] It is most essential that many species of plants be tested in order that we may determine what classes of reaction to ions are peculiar to certain groups of organisms and what, if any, may

[1] Festschrift für Adolf Fick, p. 111 (1899).

[2] See the papers of Garrey, Anne Moore, Cushing, Lillie, and Stiles cited in the Bibliography, (p. 56). True has lately experimented with *Cladophora gracilis* grown in various synthetic solutions resembling sea water, and has made the highly interesting discovery that an indefinite prolongation of life could be obtained only when a solution equivalent to sea water in its other components, but containing much more NaCl, was employed. Addition of calcium and potassium salts was found necessary in order to neutralize effectively the toxic action of a sodium salt solution.

[3] Amer. Journ. Physiology, 3, 443 (1900).

[4] For certain limitations of the theory as now formulated reference should be made to the very important paper of Kahlenberg [Journ. Physical Chem., 5, 339 (1901)].

[5] Loeb's discovery that fertilized eggs of the sea urchin could be developed to the pluteus stage in mixtures of three, but not of two chlorides, indicates that much is to be expected from such an extension of these investigations. See Amer. Journ. Physiology, 3, 441, (1900).

be regarded as generic properties of protoplasm. No less important, as Loeb's work with animals has conclusively shown, will be the comparative study of different organs and functions and stages of growth in the same plant, as to their different reactions to the same ions and combinations of ions.

From the point of view of agriculture the ion-proteid theory will doubtless throw light upon much that is now obscure and even paradoxical in the relation between the plant and the soluble components of the soil. Nothing is more certain, in the light of such observations as are recorded in this paper, than the inadequacy of soil physics and soil chemistry alone to explain many details of this relation. The chemistry of protoplasm and its proteid compounds must surely be taken into account before we may hope to get to the bottom of the subject.

STIMULATING EFFECT OF DILUTE SOLUTIONS.

As an incident of these investigations it was demonstrated that in the case of certain salts, when plant roots are exposed to pure solutions which are much too dilute to produce any toxic effect, there occurred a decidedly stimulating effect upon growth, as compared with that in the distilled-water control during a corresponding period. As would be expected, this was shown to be the case for salts of calcium, both the chloride and the sulphate acting as stimuli. Here, however, we have to do with salts which contain valuable elements of plant food.

But a marked stimulating action occurs in pure solutions of sodium carbonate (slight in 0.002 normal, marked in 0.00125 normal and of sodium bicarbonate 0.01 normal). The most pronounced effect was obtained in a 0.00125 normal solution of sodium carbonate, the average elongation of the roots in that solution being one and one-half times as great as in distilled water during the same period. In the case of the two carbonates of sodium it seems necessary to regard the effect as one of chemical stimulus, pure and simple. That this is not due to the sodium ions is evident from the fact that very dilute solutions of other sodium salts (sulphate, chloride) gave purely negative results. It was at first thought that the physiological effects of sodium carbonate (Na_2CO_3) were attributable to the presence of hydroxyl ions in the solution, since the corrosive, clearing action of more concentrated solutions of this salt is precisely similar to that produced by potassium hydrate and sodium hydrate. But toxic, as well as stimulating reactions of exactly the same character were obtained with solutions of the bicarbonate ($NaHCO_3$), in which a large excess of carbon dioxide was dissolved, and which gave no reaction with phenolphthaleine, even at the end of the experiment.[1] In this case the consideration of free hydroxyl

[1] Solutions of sodium carbonate which were many times too dilute to produce a stimulating effect, yet gave a strong reaction with phenolphthaleine.

ions must be excluded. Hence the conclusion seems unavoidable that the carbonic acid (HCO_3) ions produce the stimulating effect, improbable as this would appear. To what agency should be ascribed the characteristic toxic action (so different in kind from that of sodium sulphate and sodium chloride) of stronger solutions of sodium bicarbonate, in which no free hydroxyl could be detected, is a question to which no answer can at present be given.[1]

None of the other salts with which experiments were made in pure solution were shown to stimulate elongation of the roots, although the possibility is not excluded that solutions still more dilute than those employed will give positive results. Magnesium sulphate was found to be indifferent (neither toxic nor stimulating) at 0.0003125 normal, magnesium chloride at 0.000625 normal, sodium sulphate (nearly) at 0.002 normal, and sodium chloride[2] (approximately) at 0.005 normal.

These observations accord with the well-known principle that many violent poisons, if given in sufficiently minute doses, serve as beneficial stimuli. Familiar examples are the action of arsenic, mercury,

[1] In experiments with sodium carbonate and sodium bicarbonate as to their effect upon animals, Loeb encountered a very similar anomaly. The stimulating effect of various hydrates upon the absorption of water by a muscle immersed in a sodium chloride solution was shown to be clearly due to the hydroxyl ions, being equal in amount when equivalent solutions of hydrates were used, irrespective of the character of the basic ions [see Pflüger's Archiv, 69, 10 (1898)]. The similar effect produced by carbonates of sodium and potassium was ascribed to the same factor, the hydroxyl ions (l. c., p. 20). On the other hand, the effect of sodium carbonate (Na_2CO_3) in stimulating skeleton formation in the pluteus of a sea urchin appears to be due to the carbonic acid (HCO_3) ions, since sodium in other forms, as well as hydroxyl in the form of potassium hydrate, gave negative results [Am. Journ. Physiology, 443, (1900)].

[2] Pfeffer [Pflanzenphysiologie, Ed. 2, 1, 425] observes that possibly chlorides (e. g., sodium chloride), like so many other substances, act in dilute solutions as chemical stimuli. Storp [Biedermann's Centralbl., 13, 76 (1884)] obtained a stimulating effect upon the germination of seeds by immersing them in a 0.01 per cent solution of sodium chloride. Jarius [Landw. Versuchsst., 32, 149 (1886)] found that even a 0.4 per cent solution of sodium chloride stimulated the germination of seeds of wheat, rye, rape, maize, beans, and vetches. Jones and Orton (Bul. Vermont Agric. Exp. Station No. 56, p. 12) observed, as a consequence of the application of sodium chloride to land in order to exterminate the weed known as Orange Hawkweed (*Hieracium aurantiacum*), a marked stimulating effect upon the growth of grass in the same field. Peligot [Comptes rendus, 73, 1078 (1871)] suggests that the stimulating effect upon field crops which is sometimes obtained with sodium chloride may be due to its facilitating the decomposition of calcium phosphate and thus increasing the amount of phosphoric acid at the disposal of the plant. Kellner [Landw. Versuchsst., 32, 365 (1886)] attributes to a similar liberation of phosphoric acid the stimulating effects of iron sulphate upon plant growth recorded by Koenig and by Griffiths (see p. 49). Réveil [De l'action des poisons sur les plantes, p. 41 (1865)] found that sodium hypochlorite in a solution of 0.1 per cent stimulates germination and growth, but is injurious, especially to herbaceous plants, when applied in greater concentration.

strychnine, digitaline, etc., upon animals. Numerous investigators have obtained similar effects with plants by supplying them with very small quantities of various substances which can not be regarded as sources of plant food, such as the extremely toxic salts of some of the heavy metals. In practically all such cases, however, it is very probable that considerable hydrolysis had taken place and that the stimulation might well be attributed to the hydroxyl ions thus introduced into the solution.

Raulin experimented extensively with the fungus Aspergillus as to the effect of various metallic salts in stimulating or hindering its growth, his being among the first considerable work in this line.[1]

The well-known observations of Frank and Krüger[2] indicate that copper in small quantities (furnished by spraying with Bordeaux mixture) stimulates the growth of the potato, acting favorably upon almost every organ and function, although this metal is well known to be

[1] Ann. Sci. Nat., sér. 5, 11, 243 (1869).—The sulphates of zinc and of iron were found to produce marked stimulating effect, the former increasing the dry weight of the fungus two to three or even seven times, the latter about twice. In order to show that the acid radicle was not responsible for the results, a corresponding amount (0.06 gram of salt per 1,000 grams of culture solution) of ammonium sulphate was tried, but no stimulation was obtained. To demonstrate still more completely that basic radicles are here chiefly concerned other salts (nitrates of iron and of zinc, zinc acetate, iron citrate) were tried and yielded stimulative effects similar to those of sulphates. In cases where both iron and zinc were added to the same culture solution (e. g., zinc nitrate plus ferric citrate, or ferric sulphate plus zinc acetate, or zinc acetate plus ferric citrate) the stimulating effect was decidedly more marked than when only one base was used. When sulphates of both zinc and iron were present the effect was nearly twice as great as in the absence of the former, and was exactly twice as great as in the absence of the latter. The diminution of the stimulating effect was almost as great if instead of merely withdrawing one or the other base an equal portion of the second base was substituted for the first; in other words, when two parts of zinc (or of iron) were substituted for one part each of zinc and of iron. The stimulating effect of the different salts of zinc expresses itself in a crop from two to four and six-tenths times, that of iron in a crop one and four-tenths to two and seven-tenths times as great as in the pure culture solution.

Manganese was found to produce effects similar to those of iron and of zinc, but "less constant, less appreciable." Silica (as silicates of potassium and of sodium) when added to the culture solution increased the dry weight of Aspergillus in the ratio of 1.2 or 1.4 to 1.

Raulin wrongly concluded that zinc and silica are indispensable to this fungus, but justly emphasizes "this influence of infinitely small quantities of substances upon vegetation" (l. c., p. 253).

J. Koenig [Landw. Jahrb., 12, 837 (1883)] and Griffiths [Journ. Chem. Soc., 1884, p. 71, and 1885, p. 46] obtained evidence of a stimulating effect of iron sulphate upon the growth of plants by watering soils used in culture experiments with a solution of this salt. On the other hand Kellner [Landw. Versuchsst., 32, 365 (1886)], following the same method of experiment, obtained only negative results.

[2] Ber. d. deutsch. bot. Gesellsch., 12, 8 (1894).

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extraordinarily poisonous to plants.[1] Miani[2] records the interesting observation that in a vapor-saturated chamber the mere presence of copper in the neighborhood of but not in contact with a hanging drop of water containing spores of Ustilago and pollen grains of various plants stimulated the germination of the latter. H. Schulz[3] found that alcoholic fermentation is accelerated by the presence of a small quantity of mercuric chloride and of other substances. The development of Aspergillus and of Penicillium in glycerol cultures was stimulated, according to Pfeffer,[4] by the presence of small quantities of zinc, manganese, cobalt, etc. Subsequently numerous experiments as to chemical stimulation were made by Richards upon fungi.[5]

[1] For a classical discussion of the toxic effect of exceedingly dilute solutions of metallic salts upon the alga Spirogyra, see Nägeli, Neue Denkschr. schweizerischen Gesellsch. f. gesammt. Naturw., **33** (1893). Copper in a solution of 1 part to 1,000,000,000 of water was found to be fatal! (l. c., p. 23.) Attention has lately been redirected to the extreme toxicity of copper by Dehérain et Demoussy [Comptes rendus, **132**, 523 (1901)] and by H. Devaux (l. c., p. 717). The latter's observation that protoplasm absorbs less copper when exposed during several hours to a large quantity of a running very dilute solution (e. g., of 1 part copper to 400,000,000 parts water) than when placed for a short time in a single drop of a much more concentrated solution (1 part copper to 30,000 parts water) leaves wholly unexplained the negative results as to the extraordinary toxicity of this substance recorded by Miani [Ber. deutsch. bot. Gesellsch., **19**, 461 (1901)], who immersed his subjects for a long period in a single drop of solution. Nägeli's experiments have been more recently repeated (upon Spirogyra and other organisms) by Israel und Klingmann [Virchow's Archiv, **147**, 293 (1897)], who made careful studies of the "oligodynamic" effects produced by extremely dilute solutions of copper. A noteworthy contribution to this subject by Galeotti has lately appeared [Biol. Centralbl., **21**, 321 (1901)], in which the effect produced by a "colloidal" solution of copper [prepared after the electrical method recently described by Bredig and Müller in Zeitschr. für physik. Chemie, **31**, 258 (1899)] is compared with that of an "ionic" solution of copper sulphate containing an equivalent amount of copper. This author found that the former (colloidal) solution plasmolyzed the protoplasm of Spirogyra in a dilution (1 gram-atom copper in 12,600,000 to 126,000,000 liters of water) at which the ionic solution (of copper sulphate) produced no effect whatever. He therefore concludes that the action of the colloidal solution is a catalytic one, closely analogous to the catalyzing action of such colloidal solutions (of copper and other metals) upon hydrogen superoxide.

[2] Ber. deutsch. bot. Gesellsch., **19**, 461 (1901).

[3] Pflüger's Archiv f. die gesammte Physiol., **42**, 517 (1888).

[4] Jahrb. für wiss. Botanik, **28**, 238 (1895).

[5] Ibid., **30**, 665 (1897). Richards experimented with sulphate of iron and with salts of zinc, cobalt, nickel, and manganese, as well as other substances, using as subjects one species each of Aspergillus, Botrytis, and Penicillium. The estimation of the amount of stimulus obtained was based upon the increase in dry weight of the whole mass of mycelium in the culture as compared with that in a control free from the stimulating substance. Zinc sulphate was found to be the most powerful stimulant, while important results were also obtained with sulphates of iron, cobalt, and nickel. Salts of lithium were likewise very effective. It was found, however, that acceleration of the development of the mycelium was accompanied by an unfavorable influence upon the production of conidia, when salts of zinc or of iron, amygdaline, or morphine were added to the culture solution. In other words, a stimulation of one function or phase of development does not necessarily imply stimulation of the organism as to all its functions.

Recently an important paper upon the effect of certain chemical stimuli upon fungi and algæ has been published by Ōno.[1]

Similar results as to the stimulation of life processes afforded by the presence of small quantities of various non-nutritive substances have been obtained in experiments with animals. Loeb[2] found this to be true of certain acids, hydrates, and mineral salts, the accelerating effect produced by the solutions upon the absorption of water by muscles, the rhythmical contraction of muscles and the segmentation of eggs being attributed to hydrogen ions, hydroxyl ions, or different basic cathions, as the case may be.[3]

The as yet obscure problem of the mode of action of chemical stimuli as regards plants has been discussed by Pfeffer,[4] from whom it may be permissible to quote at some length:

"In the regulation of activity chemical stimuli certainly play a very extensive part. It is obviously a matter of chemical stimulation that the seeds of Orobanche and of Lathræa germinate only upon the roots of host plants, and probably the same occurs with fungi. In the case of initiatory or only regulatory stimuli, there may be partly involved substances which the organism does not necessarily require. In fact, under certain circumstances very different substances can cause an acceleration of activity. * * * These and similar phenomena obviously arise from different causes. Partly it may be a matter of physiological counter reactions, which can also, for example, occasion an increase of respiration, of circulation of the protoplasm, etc., in response to injurious or other action. In other cases a more simple chemical acceleration of reaction may be concerned, as in catalytic action."

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[1] Journ. Coll. Sci. Univ. Tōkyō, **13**, 141 (1900). This author experimented with various species of algæ and fungi in order to determine their reaction to minute quantities of the sulphates of zinc, nickel, iron, and cobalt as well as to sodium fluoride, lithium nitrate, and potassium arsenate. He found a marked increase in the total amount of vegetable matter produced in the presence of any one of these substances, the increase in the case of algæ being due, however, to the stimulation of vegetative reproduction rather than to any marked increase in the size of individual plants. The optimum dose for algæ is considerably smaller than that for fungi, 0.0001 gram molecule in most cases proving toxic to the former. Zinc sulphate exerts the greatest stimulating effect. These salts (especially $ZnSO_4$ and NaFl) tend to hinder the development of spores in fungi. Copper sulphate and mercuric chloride stimulate the growth of fungi, but not of algæ.

[2] See all the papers of this author cited in the Bibliography.

[3] It is probably worth while at this point to call attention to the fact that in nearly every case where this stimulative effect has been observed, electrolytes have been used which are known to show marked hydrolysis, with the formation either of hydroxyl ions, or more generally, as in the case of salts of the heavy metals, of hydrogen ions. And it may well be that, as in the studies of Loeb, the stimulating effects observed by former investigators may rightly be ascribed in the majority of cases to the presence of these ions.

[4] Jahrb. für wiss. Botanik, **28**, 238, 239 (1895).

In another work[1] Pfeffer emphasizes the idea of counter reactions, suggesting that "one has to do in this accelerating stimulation with one of the manifold reactions which serve, through more intensive activity, to counteract as far as possible an injurious influence or to compensate injuries." And again:[2] "Probably this [stimulating] effect results from a general reaction of the organism against injurious substances, since similar effects are induced by ether, alkaloids, etc., effects which also find expression in an increase of fermentation and respiration. * * * It is easy to understand * * * that furthermore such substances as are poisonous only in higher concentration generally occasion no obvious [stimulating] effect."

If it can be shown that such stimulating effect is sufficiently permanent to express itself in a marked increase in the yield of a crop, its economic importance would be obvious. That the presence of a certain amount of calcium salts in the soil may really act as a chemical stimulant to growth, apart from the value of the salts as plant food, or in rendering soluble other nutritive soil components there appears to be some reason to believe. It is not impossible that other substances, even perhaps those salts of magnesium and of sodium which constitute the most noxious components of alkali soils, when present in quantity too small to be harmful, may be actively stimulative rather than merely indifferent to plants. That several of them are likewise valuable as sources of nutritive material is well known. Whether, after all, the distinction between the chemically stimulating effect and the utility as food of certain mineral salts be always as sharp as is commonly supposed, is a question which can not yet be regarded as decisively answered.

ECONOMIC IMPORTANCE OF THE RESULTS.

Some of the facts ascertained by these experiments with salt solutions in their effect upon plants have a direct practical bearing upon agricultural conditions and methods in regions where alkali salts are frequent. Attention is particularly directed to the effects obtained by the addition of lime salts to others. Each of the common soluble alkali salts is found to be very injurious when alone, but usually much less harmful when two are mixed, especially when a salt of lime is one component of the mixture. This is strikingly the case with sulphates of magnesium and of sodium, the noxious effects of these salts being enormously lessened by the application of lime, particularly in the form of gypsum or land plaster (the dihydrate of calcium sulphate). Contrary to the general impression, this corrective effect was found in water-culture experiments to be considerably less for "black alkali" (sodium carbonate) than for any of the "white alkali" salts, although even the harmfulness of black alkali can certainly be greatly diminished by the use of gypsum.

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[1] Pflanzenphysiologie (Zweite Auflage), 1, 374 (1897).
[2] Ibid., p. 409.

The soluble chloride of lime could apparently also be used to advantage upon a soil which is strongly impregnated with alkali. With this salt the best effects would be anticipated when it is used as a remedy for black alkali, although it is likewise a powerful antidote for the chloride and sulphate of soda and of magnesia. But, except in rare instances, the use of chloride of lime upon a large scale is hardly practicable. The little-soluble carbonate of lime is likewise more or less beneficial in all cases except that of black alkali, but it is a much less powerful remedy than is land plaster (calcium sulphate).

Much economic value should attach to an extension of these experiments by using mixtures of more than two salts. It would thus be possible to imitate more closely the conditions which obtain in alkali soils, where several or all of these salts usually occur together. Furthermore, other kinds of plants should be tried in order to determine to what extent plants differ one from another in their power to resist the effect of various combinations of alkali salts. In this connection experiments should be made with wheat, barley, sugar beets, and other important crops of the region, as it may be found that one crop is better adapted than another to withstand the effects of this or that type of alkali soil.

This leads to the possibility of selecting alkali-resistant breeds of each of the leading crops. By observation of a stand of wheat or of alfalfa which has been injured by the "rise of alkali" or by the use of alkaline irrigating water, it is usually possible to find here and there individual plants which have succeeded in surviving the injurious effects of the salts. Similar differences in the power of individuals to resist the action of alkali salts was detected in the culture experiments. By continued selection of the seed of such resistant individuals, sowing it season after season in alkali soil, there is reason to hope that in time a race could be developed and fixed which would flourish in soils containing a greater amount of alkali than can be endured by the ordinary agricultural varieties.[1] It will likewise be very interesting to determine whether a race bred to resist black alkali, for example, will also prove to be proportionately resistant to white alkali, or whether it will be possible and desirable to develop different races to suit different types of alkali soil. An observation already cited (see p. 34) would indicate that the different power of resistance possessed by individuals of the same species of plant is brought out

[1] Observations made by Roos, Rousseaux, and Dugast [Ann. de la Science Agron., sér. 2, 6ième année, 2, 336 (1900)] indicate such differences among the grapes cultivated in Algeria. It was found that of different varieties growing in the same soil the fruit of some absorbed less sodium chloride from the soil than was taken up by others. As the sale of wine containing too high a content of sodium chloride is prohibited by law in France, the economic importance of this discovery is obvious. Although the problem here involved is somewhat different from that of the power of resistance to the poisonous effects of a salt upon the plant, it serves to illustrate the general principle that different individuals or races show marked dissimilarity in their behavior in the presence of a given soil component.

more sharply in the presence of the carbonates of soda than when other "alkali" salts are concerned.

So great appears to be the promise of results to be obtained by breeding alkali-resistant races of the more important field crops of the far western United States, that the Department of Agriculture has already undertaken work on this line. During the past season experiments with this end in view were begun under the direction of Mr. Webber, of the Plant-Breeding Laboratory, Division of Vegetable Physiology and Pathology. It is hoped that they will demonstrate the practical value of this method of approaching the problem.

SUMMARY.

As the result of these preliminary studies, the following facts can be regarded as established:

(1) Those readily soluble salts of magnesium and of sodium which are characteristic components of alkali soils are exceedingly injurious to plants when exposed to pure solutions of them of concentration above a minimum which is specific for each.

(2) They are toxic in the following sequence, beginning with the most harmful: Magnesium sulphate, magnesium chloride, sodium carbonate, sodium sulphate, sodium chloride, and sodium bicarbonate.

(3) Calcium chloride in pure solution is ten times less injurious than sodium chloride, and two hundred times less injurious than magnesium sulphate, if chemically equivalent solutions are considered.

(4) Magnesium carbonate in a saturated solution is not markedly injurious, while magnesium bicarbonate in saturated solution acts as a strong poison. Calcium carbonate and calcium sulphate are positively stimulating in saturated solutions, while calcium bicarbonate appears to be decidedly injurious.

(5) The toxic effect of the injurious salts is due very much more to the influence of the cathions (derived from the basic radicle) than to the anions (furnished by the acid radicle).

(6) By mixture of equal volumes of two readily soluble salts, or by the addition of a solid excess of a relatively insoluble to a solution of an easily soluble salt, the toxic effect of the more harmful component can in a majority of cases be diminished, or the concentration of the more toxic salt endurable by the roots of plants can be increased.

(7) This increase is much greater in cases where a different kind of cathion is added to the solution than when a new anion only is introduced.

(8) Addition of sodium ions to a solution containing magnesium ions in most instances markedly weakens the toxic action of the latter.

(9) Addition of calcium ions to solutions containing either sodium or magnesium ions nearly always counteracts to an extraordinary degree the injurious effect of the sodium or magnesium ions, this beneficial influence being usually much more marked when calcium is furnished as the sulphate than when the chloride is added.

(10) The ameliorating effect of calcium sulphate is much more marked when it is added to sulphates of magnesium and of sodium than when it is mixed with the corresponding chloride. It raises the concentration limit endurable by plant roots in magnesium sulphate four hundred and eighty times, in sodium sulphate more than sixty times.

(11) Even plasmolysis, although supposedly a reaction to purely physical stimuli, can apparently be completely prevented by altering the chemical nature of a solution without materially diminishing its osmotic pressure. At any rate, plasmolysis was not detected in cases where a solid excess of calcium sulphate had been added to a 0.3 or even 0.4 normal solution of magnesium sulphate, although a pure solution of magnesium sulphate is very strongly plasmolyzing at the concentrations named.

(12) Calcium chloride appears to be peculiarly effective in neutralizing the effect of sodium carbonate.

(13) The effect of one kind of ion in counteracting the physiological action of another kind can not be entirely explained by a study of the chemistry of the solution itself, but must in part be referred to complicated changes in the protoplasm of the organisms. The theory that ions furnished by the dissociation of electrolytes form intimate combinations with the proteids of protoplasm, and that their mutually antagonistic effect expresses itself in a replacement of one kind of ion by another as a result of change in the composition of the surrounding solution, would appear to afford the key to this problem.

(14) At a certain degree of dilution all of these salts become indifferent (i. e., neither toxic nor stimulating) in their action upon plant tissues. The maximum concentration of the indifferent solution is likewise specific for each salt.

(15) At a still greater dilution some of them, as the salts of calcium and the two carbonates of sodium, produce a positively stimulating effect upon the growth of roots.

(16) Individual plants show a marked dissimilarity in their power of resistance to the toxic action of the alkali salts. Such individual differences are strikingly accentuated in solutions of sodium carbonate and of sodium bicarbonate of the maximum concentration which will permit any of the roots to retain their vitality.

CONCLUSION.

Too great stress can not be laid upon the fact that the experiments upon which the present report is based are merely preliminary. Furthermore, they were designed primarily to afford a standard for comparison of the salts involved. It is not to be expected—indeed, it is assuredly not true—that in the soils containing these salts the conditions are quite comparable to those maintained in the laboratory in the course of these investigations. The physical nature of the soil, as well as the presence of various other soluble substances, renders it

certain that nowhere in the field will these salts be found to have anything like the poisonous effect which they severally exert upon the roots of plants immersed in water solutions. Nevertheless it is only from such experiments, conducted under simplified conditions, that we can draw conclusions as to the actual effect of the components of alkali soils upon plant growth.

It is very desirable that this line of investigation be continued and extended. Further combinations, perhaps of more than two salts, should be tested; an attempt should be made to imitate as closely as possible natural soil conditions; plants in different stages of growth should be tried, for in irrigated regions it often happens that a standing crop is exposed to a varying soil content of soluble salts at different periods of its development. Finally, it is highly important that the experiments be repeated with other plants of widely different relationship and, as far as possible, of actual agricultural importance in the region concerned. For while we may assume for the present that the same sequence of harmfulness of the several salts will obtain in the case of most or all ordinarily cultivated plants, this is open to doubt, and it is quite certain that the actual limits of endurance differ in the case of different plants.

BIBLIOGRAPHY.

ASKENASY, E.—Ueber einige Beziehungen zwischen Wachsthum und Temperatur. Ber. deutsch. bot. Gesellsch., **8**, 61 (1890).

BODLÄNDER, G.—Ueber die Löslichkeit der Erdalkalikarbonate in Kohlensäurehaltigem Wasser. Zeit. für physik. Chem., **35**, 25 (1900).

BREDIG & MÜLLER.—Ueber anorganische Fermente. I. Ueber Platinkatalyse und die chemische Dynamik des Wasserstoffsuperoxyd. Zeit. für physik. Chem., **31**, 258 (1899).

CAMERON, F. K.—Application of the theory of solution to the study of soils. Report 64, U. S. Department of Agriculture, pp. 141 to 172 (1900).

CAMERON, F. K.—Soil solutions. Bulletin No. 17, Division of Soils, U. S. Department of Agriculture (1901).

CAMERON, F. K.—Solubility of gypsum in aqueous solutions of sodium chloride. Bulletin No. 18, Division of Soils, U. S. Department of Agriculture; Journ. Physical Chem., **5**, 556 (1901).

CAMERON & BRIGGS.—Equilibrium between carbonates and bicarbonates in aqueous solution. Bulletin No. 18, Division of Soils, U. S. Department of Agriculture (1901); Journ. Physical Chem., **5**, 537 (1901).

CAMERON & SEIDELL.—Solubility of gypsum in aqueous solutions of certain electrolytes; solubility of calcium carbonate in aqueous solutions of certain electrolytes in equilibrium with atmospheric air. Bulletin No. 18, Division of Soils, U. S. Department of Agriculture (1901).

CLARK, J. F.—Electrolytic dissociation and toxic effect. Journ. Physical Chem., **3**, 263 (1899).

CLARK, J. F.—On the Toxic Value of Mercuric Chloride and its Double Salts. Journ. Physical Chem., **5**, 289 (1901).

COUPIN, H.—Sur la toxicité du chlorure de sodium et de l'eau de mer à l'égard des végétaux. Rév. Gén. de Botanique, **10**, 177 (1898).

COUPIN, H.—Sur la toxicité des composés du sodium, du potassium et de l'ammonium à l'égard des végétaux supérieurs. Rév. Gén. de Botanique, **12**, 177 (1900).

COUPIN, H.—Sur la résistance aux agents chimiques du protoplasma à l'état de vie ralentie. Comptes rendus Soc. Biol., **53**, 541 (1901).

COUPIN, H.—Sur la sensibilité des végétaux supérieurs à des doses très faibles de substances toxiques. Comptes rendus Acad. Paris, **32**, 645 (1901).

COUPIN, H.—Sur la sensibilité des végétaux supérieurs à l'action utile des sels de potassium. Ibid., 1582.

CUSHING, H.—Concerning the poisonous effect of pure sodium chloride solutions upon the nerve-muscle preparation. Amer. Journ. Physiology, **6**, 77 (1901).

CURTIS, C. C.—Turgidity in mycelia. Bul. Torr. Bot. Club, **27**, 1 (1900).

DANDENO, J. B.—The application of normal solutions to biological problems. Bot. Gazette, **32**, 229 (1901).

DEHÉRAIN & DEMOUSSY.—Sur la germination dans l'eau distillé. Comptes rendus Acad. Paris, **132**, 523 (1901).

DEVAUX, H.—De l'adsorption des poisons métalliques très dilués par les cellules végétales. Ibid., p. 717.

DRUDE, O.—Handbuch der Pflanzengeographie. Stuttgart (1890).

ENGEL, M. R.—Sur la dissolution du carbonate de magnésie par l'acide carbonique. Comptes rendus Acad. Paris, **100**, 444 (1885).

ENGEL, M. R.—Sur la formation de l'hydrocarbonate de magnésie. Ibid., p. 911.

ESCHENHAGEN.—Ueber den Einfluss von Lösungen verschiedener Concentration auf das Wachsthum der Schimmelpilze. Stolp (1889).

FRANK und KRÜGER.—Ueber den Reiz, welchen die Behandlung mit Kupfer auf die Kartoffelpflanze hervorbringt. Ber. deutsch. bot. Gesellsch., **12**, 8 (1894).

FREITAG, C. J. DE.—Ueber die Einwirkung concentrirter Kochsalzlösungen auf das Leben von Bakterien. Archiv für Hygiene, **11**, 60 (1890).

GALEOTTI, G.—Ueber die Wirkung kolloidaler und elektrolytisch dissoziirter Metalllösungen auf die Zellen. Biol. Centralbl., **21**, 321 (1901).

GARREY, W. E.—The effects of ions upon the aggregation of flagellated infusoria. Amer. Journ. Physiology, **3**, 291 (1900).

GRIFFITHS, A. B.—Researches on the growth of plants under special conditions. Chem. News, **47**, 27 (1883).

GRIFFITHS, A. B.—Experimental investigations on the value of iron sulphate as a manure for certain crops. Journ. Chem. Soc. London. **45**, 71 (1884).

GRIFFITHS, A. B.—On the application of iron sulphate in agriculture and its value as a plant food. Ibid. **47**, 46 (1885).

HEALD, F. D.—On the toxic effect of dilute solutions of acids and salts upon plants. Bot. Gazette, **22**, 125, t. 7 (1896).

HILGARD, E. W.—Nature, value, and utilization of alkali lands. Bul. No. 128, Agr. Exp. Sta. Univ. of California (1900).

ISRAEL & KLINGMANN.—Oligodynamische Erscheinungen (v. Nägeli) an pflanzlichen und tierischen Zellen. Virchow's Archiv, **147**, 293 (1897).

JARIUS, M.—Ueber die Einwirkung von Salzlösungen auf den Keimungsprocess der Samen einiger einheimischen Culturgewächse. Landw. Versuchsst., **32**, 149 (1886)

JENTYS, S.—Sur l'influence de la pression partiale de l'acide carbonique dans l'air souterrain sur la végétation. Bul. Internat. Acad. Sci., Cracovie (1892), 306 (1893).

JONES & ORTON.—Orange Hawkweed or "Paint Brush." Bul. No. 56, Vermont Agric. Exp. Sta. (1897).

KAHLENBERG, L.—The theory of electrolytic dissociation as viewed in the light of facts recently ascertained. Journ. Physical Chem., **5**, 339 (1901).

KAHLENBERG and AUSTIN.—Toxic action of acid sodium salts on Lupinus albus. Journ. Physical Chem., **4**, 553 (1900).

KAHLENBERG and MEHL.—Toxic action of electrolytes upon fishes. Journ. Physical Chem., **5**, 113 (1901).

KAHLENBERG and TRUE.—On the toxic action of dissolved salts and their electrolytic dissociation. Bot. Gazette, **22**, 81 (1896).

KELLNER, O.—Untersuchungen über die Wirkung des Eisenoxyduls auf die Vegetation. Landw. Versuchsst., **32**, 365 (1886).

KLEMM, P.—Desorganisationserscheinungen der Zelle. Jahrb. für wiss. Botanik, **28**, 627. tt. 8, 9 (1895).

KNOX, W. F.—Ueber das Leitungsvermögen wasserigen Lösungen der Kohlensäure. Ann. Phys. Chem., **54**, 44 (1895).

LILLIE, R.—On differences in the effects of various salt solutions on ciliary and on muscular movements in Arenicola larvæ. Amer. Journ. Physiology, **5**, 56 (1901).

LOEB, J.—Physiologische Untersuchungen über Ionenwirkungen. Mitth. 1. Pflüger's Archiv für die gesammte Physiologie, **69**, 1 (1898); Mitth. 2, l. c., **71**, 457 (1898).

LOEB, J.—Ueber die Aehnlichkeit der Flüssigkeits-resorption in Muskeln und in Seifen. Ibid., **75**, 303 (1899).

LOEB, J.—Ueber die Bedeutung der Ca- und K-Ionen für die Herzthätigkeit. Ibid., **80**, 229 (1900).

LOEB, J.—Ueber Ionen welche rhythmische Zuckungen der Skelett-muskeln hervorrufen. Festschrift für Adolf Fick 101, Braunschweig (1899).

LOEB, J.—On the nature of the process of fertilization and the artificial production of normal larvæ (plutei) from the unfertilized eggs of the sea urchin. Amer. Journ. Physiology, **3**, 135 (1899).

LOEB, J.—On ion-proteid compounds and their rôle in the mechanics of life phenomena. 1. The poisonous character of a pure NaCl solution. Ibid., 327 (1900).

LOEB, J.—On the different effect of ions upon myogenic and neurogenic rhythmical contractions and upon embryonic and muscular tissue. Ibid., 383 (1900).

LOEB, J.—On the artificial production of normal larvae from the unfertilized eggs of the sea-urchin (Arbacia), Ibid., 434 (1900).

LOEB, J.—Further experiments on artificial parthenogenesis and the nature of the process of fertilization. Ibid., **4**, 178 (1900).

LOEB, J.—Experiments on artificial parthenogenesis in annelids (Chætopterus) and the nature of the process of fertilization. Ibid., 423 (1901).

LOEB, J.—On an apparently new form of muscular irritability produced by solutions of salts (preferably sodium salts) whose anions are liable to form insoluble calcium compounds. Ibid., **5**, 362 (1901).

LOEW, O.—The physiological rôle of mineral nutrients. Bul. No. 18, Div. Veg. Phys. and Path., U. S. Dept. Agric. (1899).

LOPRIORE, G.—Ueber die Einwirkung der Kohlensäure auf das Protoplasma der lebenden Pflanzenzelle. Jahr. für wiss. Botanik, **28**, 531, tt. 6, 7 (1895).

MIANI, D.—Ueber die Einwirkung von Kupfer auf das Wachsthum lebender Pflanzenzellen. Ber. deutsch. bot. Gesellsch., **19**, 461 (1901).

MOORE, ANNE.—The poisonous action of saline solutions. Amer. Journ. Physiology, **4**, 386 (1900).

MOORE, ANNE.—The effect of ions on the contraction of the lymph hearts of the frog. Ibid., **5**, 87 (1901).

NÄGELI, C.—Ueber oligodynamische Erscheinungen in lebenden Zellen. Neue Denkschr. d. schweizerischen Gesellsch. für die gesammten Naturwiss., **33**, 51 pp. (1893).

ÖNO, N.—Ueber die Wachsthumsbeschleunigung einiger Algen und Pilze durch chemische Reize. Journ. Coll. Sci. Imp. Univ. Tōkyō, **13**, 141, t. 13 (1900).

OVERTON, E.—Ueber die osmotischen Eigenschaften der lebenden Pflanzen- und Tierzelle. Vierteljahrsschr. Naturf. Gesells ch. Zürich **40**, 1 (1895).

PAULI, W.—Ueber physikalisch-chemische Methode und Probleme in der Medizin. Wien (1900).

PELIGOT, E.—Sur la répartition de la potasse et de la soude dans les végétaux. Comptes rendus Acad. Paris, **73**, 1072 (1871).

PFEFFER, W.—Ueber Aufnahme von Anilinfarben in lebende Zellen. Unters. aus der bot. Institut Tübingen, **2**, 179 (1886).

PFEFFER, W.—Ueber Election organischer Nährstoffe. Jahrb. für wiss. Botanik, **28**, 205 (1895).

PFEFFER, W.—Pflanzenphysiologie. Ein Handbuch der Lehre vom Stoffwechsel und Kraftwechsel in der Pflanze. Zweite Auflage, erster Band (1897).

PFEIFFER, E.—Ueber die electrische Leitungsfähigkeit des kohlensauren Wassers und eine Methode, Flüssigkeitswiderstände unter höhen Drucken zu messen. Ann. Phys. Chem., **23**, 625 (1884).

RAULIN, J.—Études chimiques sur la végétation. Ann. des Sci. Nat., sér. 5, **11**, 93 (1869).

RÉVEIL.—Recherches de physiologie végétale. De l'action des poisons sur les plantes. Paris (1865). [1]

RICHARDS, H. M.—Die Beeinflussung des Wachsthums einiger Pilze durch chemische Reize. Jahrb. für wiss. Botanik, **30**, 665 (1897).

RICHTER, A.—Ueber die Anpassung der Süsswasseralgen an Kochsalzlösungen. Flora, **75**, 4, tt. 1, 2 (1892).

ROOS, ROUSSEAUX et DUGAST.—Rapport sur les vins des terrains salés de l'Algérie. Ann. de la Sci. Agronom., sér. 2, 6ième année, **2**, 276 (1900).

SACHS, J.—Ueber den Einfluss der chemischen und physikalischen Beschaffenheit des Bodens auf die Transspiration der Pflanzen. Landw. Versuchsst., **1**, 203 (1859); Gesammelte Abhandl., **1**, 417 (1892).

SACHS, J.—Ueber das Wachsthum der Haupt- und Nebenwurzeln. Arbeiten des bot. Instituts Würzburg **1**, 385, 584 (1873–74); Gesammelte Abhandl., **2**, 773 (1893).

SCHIMPER, A. F. W.—Pflanzengeographie auf physiologischer Grundlage. Jena (1898).

SCHLOESING, TH.—Sur la dissolution du carbonate de chaux par l'acide carbonique. Comptes rendus Acad. Paris, **74**, 1552 (1872).

SCHULZ, H.—Ueber Hefegifte. Pflüger's Archiv für die gesammte Physiologie, **42**, 517 (1888).

SIGMUND, W.—Ueber die Einwirkung Chemischer Agentien auf die Keimung, Landw. Versuchsst. **47**, 1 (1896).

STANGE, B.—Beziehungen zwischen Substratconcentrationen, Turgor und Wachsthum bei einigen phanerogamen Pflanzen. Bot. Zeitung, **50**, 253 (1892).

STEWART, JOHN.—Effect of alkali on seed germination. Ninth Ann. Rep. Utah Agr. Exp. Sta. p. 26 (1898).

STILES, P. J.—On the rhythmic activity of the œsophagus and the influence upon it of various media. Amer. Journ. Physiology, **5**, 338 (1901).

STORP, KÖNIG u. a.—Ueber den Einfluss von Kochsalz-und Zinksulfathältigem Wasser auf Boden und Pflanzen. Biederm. Centralbl., **13**, 76 (1884).

TREADWELL & REUTER.—Über die Löslichkeit der Bikarbonate des Calciums und Magnesiums. Zeitschr. für anorgan. Chemie, **17**, 170 (1898).

TRUE, R. H.—On the influence of sudden changes of turgor and of temperature on growth. Ann. of Botany, **9**, 365 (1895).

TRUE, R. H.—The physiological action of certain plasmolyzing agents. Bot. Gazette, **26**, 407 (1898).

[1] An extensive bibliography of the earlier literature of the subject is given by this author (pp. 169 to 176).

TRUE, R. H.—The toxic action of a series of acids and of their sodium salts on Lupinus albus. Amer. Journ. Sci., ser. 4, 9, 183 (1900).

VRIES, H. DE.—Eine Methode zur Analyze der Turgor. Jahrb. für wiss. Botanik, 14, 427 (1884).

WALKER & CORMACK.—Dissociation constants of very weak acids. Journ. Chem. Soc. 77, 5 (1900).

WHITNEY & MEANS.—Alkali soils of the Yellowstone Valley. Bul. 14, Div. Soils, U. S. Dept. Agric. (1898).

WOLF, W.—Die Saussure'chen Gesetze der Aufsaugung von einfachen Salzlösungen durch die Wurzeln der Pflanzen. Landw. Versuchsst., 6, 203 (1864.)

WOLF, W.—Chemische Untersuchungen über das Verhalten von Pflanzen in der Aufnahme von Salzen aus Salzlösungen, welche zwei Salze gelöst enthalten. Ibid., 7, 193 (1865).

FORMATION OF SODIUM CARBONATE, OR BLACK ALKALI, BY PLANTS.

By FRANK K. CAMERON.

INTRODUCTION.

Considerable attention has been paid within the past few years to the possibility of growing valuable forage crops on some of the alkali soils of the arid West. This subject was first taken up in California.[1] The great value of saltbushes for certain soil conditions and for certain kinds of cattle feeding seems to be well established, but as both Hilgard and Goss[2] have pointed out there is an element of danger, expressed in the prevalent belief that most of these plants, including the greasewood, chico, and other indigenous plants, convert the less harmful neutral salts, such as sodium chloride and sodium sulphate, into alkali carbonates—that is to say, the less harmful "white alkali" is converted into the more noxious "black alkali," as has been shown by the presence of sodium carbonate immediately under such plants, whereas no trace of it exists some distance away. It may be possible that the plants with their enormous root systems actually gather up minute traces of sodium carbonate, which may be present in lower depths of soil, gradually causing an accumulation at the surface on the decay of their roots and branches. But the generally accepted hypothesis of the conversion of the neutral salts appears more probable, as will be seen in the course of this paper. It would seem probable that plants growing in bunches or mats would be more effective in producing these localized black-alkali spots, but some of the most striking illustrations of this phenomenon have been observed in connection with more upright species, such as *Sarcobatus vermiculatus*, the common "greasewood" of the West.

In the study of the alkali soils of the arid regions the field parties of the Division of Soils have found the local flora of great value in indicating the character of the particular soils where they are found. This apparent relation between the plant and the salts present in the soil became of interest in this connection and was referred to the

[1] University of California, Agricultural Experiment Station, Bul. No. 125 (1899).

[2] New Mexico College of Agriculture and Mechanical Arts, Agricultural Experiment Station, Bul. No. 22, p. 41 (1897).

laboratory for consideration. The results of some preliminary investigations have proved of such interest as to warrant immediate publication.

CREOSOTE BUSH.

A specimen of the creosote bush[1] (*Covillea tridentata*) was examined. This, while a desert plant, is said to shun soils where there is much water-soluble salts. Mr. Means states that its presence can be taken as a sure indication of land free from injurious quantities of alkali. It is found in dry, well-drained upland soils.

The material was thoroughly air dried. The leaves and stems were then carefully separated, and both of the separated samples were ground fine in an agate mortar. A portion of each sample was burned to ash. The finely ground air-dried material and the ash were each carefully leached with successive small portions of water until the leachings ceased to show the presence of chlorides. The leachings in each case were then brought together and made up to a volume of 500 cubic centimeters, and the various determinations were made with 100 cubic centimeter portions. The carbonates[2] were determined by titrating with a twentieth normal (N/20) solution of hydrogen potassium sulphate until loss of color, using phenolphthaleine as indicator. So soon as the color had disappeared a drop or two of a solution of potassium chromate was added and the chlorine determined by titrating with a tenth normal (N/10) solution of silver nitrate. The sulphates, when determined, were estimated gravimetrically as barium sulphate in the usual manner. For convenience the acids thus found to be present are stated as the corresponding sodium salts. This procedure seemed to be justified by a subsequent determination of the amount of sodium present in the solution. It is a well established fact, and a familiar one to chemists, that when a salt of an alkali metal is burned down with charcoal or other organic matter a part of the mineral acid is volatilized and driven off, the alkali base forming a carbonate, which is a stable compound even at quite high temperatures. Nevertheless this is a point often overlooked in the discussion of ash analyses. In obtaining the ashes the examinations of which are described in this paper, very great care was exercised to reduce the amount of this loss of the mineral acid as far as possible, and the burning was done at as low a temperature as possible. In some cases the large amount of fused salt in the burning ash coated the charred organic matter in such a way as to render further combustion at a comparatively low temperature quite impossible. In these cases the combustion was stopped, the fused salts leached out with water, and the residue reburned. It seems probable, as will appear from the results which will be presented, that the loss of mineral acids

[1] Collected by Mr. Thos. H. Means near Tempe, Ariz.; kindly identified for us by Mr. F. V. Coville.

[2] Report 64, Division of Soils, U. S. Dept. Agr. (1900); Amer. Chem. Jour., 23, 571 (1900). Bul. 18, p. 77, Division of Soils, U. S. Department of Agriculture (1901).

in the burning of the plant to ash was kept down to a very small percentage by following the procedure described.

The data obtained on examination of the ashes from the creosote bush are presented in the following table:

TABLE XII.—*Analysis of the ash of the creosote bush.*

	Leaves.	Leaves and small stems.	Stems.
Weight of sample, grams	8.5659	3.6942	6.6445
Weight of ash, grams	.8282	.3795	.3710
Ash, per cent of plant	9.66	10.27	5.58
Na_2CO_3, per cent of ash	8.90	13.18	17.73
NaCl, per cent of ash	5.71	5.37	3.55
Na_2CO_3, per cent of air-dried plant	.86	1.35	.99
NaCl, per cent of air-dried plant	.55	.55	.19

The dry leaves, which had been ground fine in a mortar, were extracted with distilled water at the room temperature in the manner described above. The extract failed to show the presence of either sodium carbonate or sodium chloride, but appeared to be slightly acid. An extract made by boiling the leaves with water also failed to show any chlorides or carbonates.

From the facts which have been presented it would appear that while the plant does contain chlorine there is no sodium chloride present as such, and therefore it is probable that the chlorine is in organic combination although nothing is definitely known of the presence of such combinations in plants. The sodium is largely in excess of the amount required to balance the chlorine as sodium chloride. This fact was shown by an actual determination of the sodium.[1] It would seem, therefore, that at least a large part of the sodium in the plant is in organic combination, possibly with some organic acid, and, on combustion or ultimate decay of the plant tissues, much sodium carbonate would be formed, as was found to be the case when the plant was reduced to ash in the laboratory.

It is interesting to note that the mineral constituents, as shown by the ash analyses, had accumulated in the leaves to about twice the amount in which they were held by the stems. The difference is very much less, however, if we consider only the water-soluble constituents in the ashes. Assuming, for the sake of argument, that the base in combination with the carbonic acid and chlorine as determined was entirely sodium, its distribution is shown by the following table:

TABLE XIII.—*Distribution of sodium in leaves and stems.*

Part of plant.	Percentages calculated for ash.			Percentages calculated for air-dried plant.		
	From Na_2CO_3.	From NaCl.	Total.	From Na_2CO_3.	From NaCl.	Total.
Leaves	3.86	2.25	6.11	0.37	0.22	0.59
Stems	7.69	1.40	9.09	.43	.07	.50

[1] Unfortunately it was not anticipated at the time this determination was made that the exact figure would be required in this discussion, and the data were not entered in the laboratory notebook and have been mislaid.

It appears that in the leaves there was about 2.7 times as much sodium as was necessary to balance the chlorine, while in the stems there was more than seven times as much of the base as the acid would require. This suggests the possibility that the chlorine was being eliminated through the leaves, probably in the form of some volatile compound, which may be the source of the odor from the plant. This idea is brought out somewhat more strikingly, perhaps, by noting that the analytical figures given above indicate that the total amount of water-soluble mineral constituents in the leaves is 1.19 times the amount in the stems, but that the amount of chlorine in the leaves is 2.75 times that found in the stems; from which it would appear that the chlorine was being concentrated in the leaves and, as has been pointed out, was there present, in all probability, in organic combination. This is a point which merits further attention, and it is hoped that it will be the subject of a more thorough investigation in the future.

GREASEWOOD.

A more thorough examination of a specimen of greasewood[1] (*Sarcobatus vermiculatus*) was made. This is a typical "alkali plant," its presence being usually regarded as a good indication of much water-soluble material in the soil. Mr. Means reports that whenever he has observed it the soil generally shows the presence of sodium carbonate, the only exception being in Montana, where the soluble salts are entirely sulphates. It would appear that this latter statement warrants further examination of the locality mentioned.

The analytical results obtained from examination of the ashes follow:

TABLE XIV.—*Analysis of the ash of the greasewood plant.*

	Leaves[1] and blossoms (1).	Leaves and blossoms (2).	Stems.
Weight of sample, grams	10.6395	5.0000	10.6817
Weight of ash, grams	2.7505	1.1736	.5274
Ash, per cent of plant	25.85	23.47	4.94
Na_2CO_3, per cent of ash	51.93	57.90	29.46
NaCl, per cent of ash	20.47	22.24	14.31
Na_2SO_4, per cent of ash	7.97	.....	3.69
Na_2CO_3, per cent of air-dried plant	13.43	13.69	1.45
NaCl, per cent of air-dried plant	5.29	5.22	.71
Na_2SO_4, per cent of air dried plant	2.06	.....	1.18

[1] Owing to the relatively large amount of fused salts which coated the carbon or other organic matter, this latter could not be completely burned off when reducing such a large sample to ash.

Five grams of leaves and blossoms, by successive leachings with distilled water at room temperature until the leachings aggregated 2 liters, gave (1) 5.81 and (2) 5.68 per cent of sodium chloride. In both experiments the washings showed no trace of soluble carbonates, but were slightly acid. The residue from (1) after ignition gave a trace of sodium chloride and 0.04 per cent of sodium carbonate.

[1] Collected by Mr. Frank D. Gardner near Salt Lake, Utah.

By the method of Carius—that is, heating in sealed tubes with fuming nitric acid and silver nitrate—

(1) 0.2327 gram of leaves and blossoms gave 0.0310 gram AgCl, equivalent to 5.43 per cent of sodium chloride.

(2) 1.0759 grams of leaves and blossoms gave 0.1432 gram AgCl, equivalent to 5.43 per cent of sodium chloride.

From these results it would appear that the plant contains chlorine, but, within the limits of experimental error, all the chlorine is present as sodium chloride, which can be leached out with water at ordinary temperatures. This is probably true of the major part of the sulphates also, although this was not shown quantitatively. A striking feature is the much larger amount of ash from the leaves and blossoms than from the stems and the markedly larger percentage of the alkali salts in the ash of the former. The idea suggests itself that possibly this plant takes up and stores the salts and holds them as such until it is ready to use such part of them as it needs.[1] On the other hand, it may be, for all that we now know, that these salts are present as described only because the plants can not prevent their accumulation, and, so far from being an inherent feature of the plant's economy, it may be a most undesirable accident due to their peculiar environment, but an accident in spite of which these particular plants are able to survive.[2] But, as Schimper[3] has pointed out, this can not be true in all cases, as evidenced by the fact that halophilous plants show a tendency to take up more salts than nonhalophilous species, even when grown in nonsaline soils.

None of the chlorine, apparently, was in organic combination, this

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[1] Schimper [Indomalayische Strandflora, p. 12 (1891); Pflanzen-Geographie, p. 99 (1898)] has expressed the opinion that halophytes thrive on salty soils because of a peculiar physiological structure which enables them to reduce to a minimum the evaporation from their leaves and, in consequence, the absorption of the salt solutions in the soil through their roots. The salt content of their sap is thus kept below a certain concentration, although this concentration may, and often does, greatly exceed that which would be determined by "osmotic equilibrium."

Stahl [Bot. Zeitung, p. 139 (1894)] observes that only a few species, such as *Reaumuria hirtella*, described by Volkens [Die Flora der Aegyptisch-Arabischen Wüste, p. 27 (1887)], are known to be able to free themselves from the salt.

Diels [Jahrb. für wiss. Botanique, 32, 316 (1898)] objects that Stahl experimented with cultivated plants and that the retarded root action noted by Schimper does not take place under natural conditions, and that, as a matter of fact, and probably through the agency of malic acid, most, if not all, the halophytes rid themselves of an excess of chloride. Diel's methods of experiment, as well as the conclusions which he draws from his own premises, are criticized by W. Beneke, Jahrb. für wiss. Botanique 36, 179 (1901).

Directly bearing upon this hypothesis is an observation by Detmer [Bot. Zeitung, 42, 791 (1884)] that "organic acids under the condition prevailing for the vegetable organism are in a position to decompose chlorides with a formation of free hydrochloric acid." See also, Osborne, Report Conn. Ag. Ex. St., 1900, p. 441.

[2] Contejean, Geog. Bot., p. 71.

[3] Schimper, Pflanzengeographie, p. 101 (1898).

completely disappear on combustion, the organic combination volatilizing as such, or by decomposition yielding volatile products containing the chlorine or sulphur.[1] In evidence against this view are the results obtained in the examination of the sample of *Sarcobatus vermiculatus*, where it was found that the total amount of chlorine in the plant, as determined by the Carius method, in which there was afforded no opportunity for any of the chlorine to escape, was the same as the amount leached out of the ashes by water, within the limits of experimental error.

Another idea that presents itself is that the bases and acids are taken up by the plant in the form of salt solutions; that the plant selects and retains the bases and excretes the acid radicals in some manner as acids. It is noteworthy, in this connection, that it has been observed generally in the cases of water cultures that the nutrient solutions gradually become acid unless special conditions are introduced to prevent it. Occasionally, however, cases have been found where the culture solutions actually become alkaline.[2] The point of special importance in this connection is that either a base or an acid radical, more often the latter, is either rejected or ejected by the plant.

It seems to have been generally supposed that the acidity of these solutions was due to organic acids formed and excreted by the plant, but no satisfactory proof for this view has been adduced. The weight of evidence is now decidedly against this view. It is not at all difficult, from the point of view of the chemist, to construct a probable "mechanism" for the phenomena presented, supposing that the plant has selectively retained the basic constituents and excreted the acids, and that the acidity of the culture solutions is due to the free mineral acids. Diels's[3] investigations in this direction are particularly interesting. He found that certain halophilous plants, when placed in distilled water, steadily lost the sodium chloride they contained. He showed that the salt was not excreted as such,[4] and offers as a probable explanation that the greater amounts of malic acid—the formation of which is shown to be a usual accompaniment of growth in succulent plants, such as most of the halophytes are—decomposes the sodium chloride, forming sodium malate and hydrochloric acid, and this latter is possibly excreted by the roots.[5] The solutions become acid, but, on account of the experimental difficulties, it was not definitely proved that the

[1] It is not intended to imply that chlorine and sulphur may not play very different parts in the plant economy, but the general considerations advanced might be true for either of these or other elements.

[2] Witness the classical investigations of Stohmann, Sachs, and Knop, described by Johnson in How Crops Grow, p. 180.

[3] Loc. cit. See also Kearney, Contributions from U. S. National Herbarium, Vol. V, No. 5, p. 277 (1900); and Benecke, Jahrb. für. wiss. Botanique, 36, 179 (1901).

[4] This point was established as early as 1865 by Wolf, Landw. Versuchstt., 7 pp. 20, 211 (1865).

[5] See reference to Benecke on p. 64.

acidity was due to the presence of hydrochloric acid. It is intended that some experiments in this direction shall soon be made in the laboratory.

A somewhat simpler explanation than the one just described may be offered—simpler because it does not require that the plant must first take up the acid radical and then go through the reverse process of exuding it again. It is known with reasonable certainty that a certain amount of hydrolysis takes place in aqueous salt solutions, although the absolute amount may be, and with ordinary strong electrolytes usually is, very small indeed; nevertheless, it does take place to some extent, and it seems not impossible that the plants might show their selective properties in the solution, taking up the base more rapidly than the acid, the latter in consequence being left in greater proportion in the culture or soil solution. Of classical importance in this connection is the work of Kuhn,[1] who found that when maize was grown in a solution containing ammonium chloride, the ammonium residue was partly taken up by the plant and hydrochloric acid remained in the solution. In fact, there does not seem to be any inherent difficulty in supposing that the plant might selectively absorb any ion for which it might have a special predilection. As soon as this ion is removed from the solution the corresponding ion with its opposite charge of electricity must either be removed from the solution by precipitation or volatilization, for example, or it at once reacts with the water. Supposing the ion removed by the plant to be a base, the action of the remaining acid ion on the water must necessarily be accompanied by the liberation of oxygen from the water of the solution. Whether or not any observation of this kind has been made I do not know, but the liberation of the oxygen might very well take place so slowly as to escape detection. The question as to what becomes of the electrical energy on the ion which the plant absorbs will be answered in a consideration of the work energy, heat energy, or other equivalent forms of energy involved in the mechanism of the absorption process, and does not necessarily demand further consideration at this point.[2]

It must be admitted in all frankness that the known facts in our possession are not sufficient to justify a positive opinion as to the views just presented. They seem, however, to be founded on a rational basis and are put forward tentatively as suggestive of possible lines of investigation and the justification for formulating them here will be found in the results of future work. Whatever may be the bearing of this work on the ideas here presented, it can not fail to be of the utmost importance in throwing light upon the difficult problem of plant nutrition.

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[1] Henneberg's Journal, pp. 116 and 135 (1864).

[2] These views are not intended to imply that salts can not be taken up as such, even by nonhalophilous plants, under certain conditions. Wolf (loc. cit.) has long since shown that this may be done, and that, moreover, in such cases the process can not be a simple diffusion phenomenon.

From the data presented above it is evident that in the decay of wood or leaves or, in general, of plant tissues, alkaline carbonates are furnished to the soil. It may be that the processes of decay will furnish at the same time organic acids stronger than carbonic acid and in sufficient quantity to combine with all the bases and prevent an alkaline reaction. As has been shown in this laboratory carbonic acid itself may be formed in sufficient amounts to convert all the carbonates to the form of bicarbonates and thus prevent an alkaline reaction. There is not sufficient evidence to justify a positive statement, but it would seem probable that this can not be always the case and that in fact there is alkali formed by the decay of plant tissues. In humid regions the alkali thus formed is removed by leaching or similar processes and by chemical reactions with the other soil components, for which reactions water is necessary.

In the arid regions, such as are found in the western part of the United States, peculiar phenomena, due to the special conditions there existing, have been observed. The indigenous plants which are found on the alkali lands are comparatively few in number, both as to species and as to individuals; others have been artificially introduced. They all have the property of absorbing more or less large amounts of water-soluble mineral salts and on analysis all show characteristically large percentages of bases. When the leaves or débris from these plants have decomposed there is often found greater or less accumulation of carbonates, although before the plant was cultivated that particular region may have been quite free from soluble carbonates. The decay of any organic matter with the accompanying formation of carbonic acid in a soil containing soluble salts of the alkali metals must be expected to result in the formation of soluble carbonates, partly by dissolving lime or magnesium compounds, followed by subsequent metathetical reactions or double decompositions with the alkali salts; more slowly and in lesser degree, perhaps, but nevertheless surely, if the formation of carbon dioxide is continued, by a distribution of the base between the two acids. This last process, however, is probably of decidedly minor importance in the phenomena under consideration.

Owing to the conditions of climate and drainage existing in the arid regions these carbonates when formed are not leached away, as in the humid regions, and gradually accumulate to the more serious detriment of the soil.

COMPARISON OF ANALYSES.

For the purpose of comparison, two analyses of greasewood (*Sarcobatus vermiculatus*) ash are here quoted, the first published by Hilgard,[1] and the other by Goss and Griffin.[2]

[1] University of California, Report of Agr. Exp. Sta., p. 142 (1890).

[2] New Mexico College of Agr. and Mech. Arts, Agr. Exp. Sta., Bul. 22, p. 41 (1897).

TABLE XV.—*Two analyses of ash of greasewood plant.*

Constituents.	First analysis.	Second analysis.
	Per cent.	*Per cent.*
Ash of air-dried plants	12.03	13.12
SiO_2	11.81	3.00
K_2O	16.53	22.06
Na_2O	39.45	23.89
CaO	1.36	6.52
MgO	1.09	1.35
MnO_2		Trace.
Fe_2O_3, Al_2O_3	7.06	[1] 4.73
P_2O_5	3.51	4.12
SO_3	4.93	4.33
CO_2	0.46	23.80
Cl	15.04	8.01
	103.04	101.81
Oxygen = chlorine	3.25	1.81
	99.79	100.00

[1] By difference.

While these analyses differ considerably in details they indicate the same general conclusions; that is, the ash or decomposition products of the plant will yield a very large amount of alkali in the form of carbonates. The figures in Hilgard's analysis, he states, indicate the presence of about 25 per cent of sodium chloride; about 8 per cent of Glauber's salt ($Na_2SO_410H_2O$), and about 39 per cent sodium carbonate. Combining the figures of Goss and Griffin's analysis in the conventional way, we find about 13 per cent sodium chloride and 29 per cent sodium carbonate. The figures are misleading, for they depend upon an arbitrary calculation of the data as salts, and the effect of the other constituents can not properly be ignored. Similarly, but a qualitative comparison can be made from the data obtained by us. If it may be assumed that the leaves and stems are of equal mass in the individual plants when air dried, our results compare quite well with the analyses just cited.

Acknowledgments are due Messrs. F. D. Gardner and Atherton Seidell for assistance in the experimental work described.

SUMMARY.

It would seem as a result of the experiments described in this paper that in certain cases at least a transformation of neutral salts to the corresponding carbonates through the agency of plant growth is possible and even probable, and that this factor must be taken under consideration in determining the value and use of such plants. Some tentative suggestions are offered as to the disposition of the mineral salts in plant economy, which it is hoped will lead to more exhaustive investigations.

RESISTANCE TO BLACK ALKALI BY CERTAIN PLANTS.

By FRANK K. CAMERON.

INTRODUCTION.

While working in the San Joaquin Valley, California, during this past summer one of the field parties of the Division of Soils observed three species of plants which appeared to be characteristic growths on soils containing much "black alkali" or sodium carbonate. Superficial examination in the field brought out the fact that the stems and leaves of these three plants were quite acid, in some cases very markedly so. A possible connection was suggested between this fact and the one first noted—that these plants were all found on soils containing much sodium carbonate. Specimens were collected and sent in to the laboratory for further examination. They were kindly identified by Mr. Kearney, of the Division of Vegetable Physiology and Pathology. They consisted of three samples of *Distichlis spicata*, numbered I, II, and III; one sample of *Suaeda intermedia*, which was separated into two portions, the first numbered IV, consisting of the stems alone, and the second numbered V, being composed of leaves alone; one sample of *Atriplex bracteosa*, which was also separated into a portion numbered VI, consisting of stems alone, and a portion numbered VII, consisting of leaves alone.

Samples I, II, and III were thoroughly air dried by being allowed to remain for about two months in the sacks in which they were received at the laboratory. It should be stated that a rough determination of the acidity they displayed was made as soon as they were received in the laboratory, and the results agreed fairly well with those obtained by the more careful examination subsequently made.

Samples IV, V, VI, and VII were found to be very wet and in serious danger of fermenting when received at the laboratory. They were therefore placed in a hot-air oven and dried for several days at from 105° to 110°C. In each case the material was then cut into small pieces and kept in carefully covered beakers, to which, however, the air had free access.

METHOD OF EXAMINATION.

The method of examination was in all cases to steep the sample, which had been cut into small pieces about a centimeter in length, overnight or for about twenty hours in a convenient amount of dis-

on account of the rapid and abundant growth of fungi in the solution when evaporation of the solvent at ordinary temperatures was attempted. The solutions of the material failed to give any reactions by which it could be identified as one of the simpler and better-known organic acids. For these reasons efforts to identify it were abandoned temporarily and further work on it postponed until a time when a larger amount of the material could be obtained. It is confidently believed that the experience thus far gained will insure a successful issue to the next attempt in this direction.

HYDROSCOPIC SALT ON THE PLANT SURFACE.

The analytical results would indicate that calcium chloride as such was on the grass, but if present no signs of it were observed on the air-dried material. The samples were all thoroughly dry and not the least evidence of any deliquescent substance on the surface was apparent. It should be remembered, however, that the evidence obtained in the examination of the organic acid indicated that the calcium salt was much less soluble than the sodium or potassium salt. In all probability the greater part of the calcium in combination in the solid phase and not in the form of calcium sulphate was present as the calcium salt of the organic acid; and the greater part of the sodium which was assumed above to be in combination with the organic acid was in reality in combination with the chlorine, which the analysis as stated assumes to be combined with calcium.

On the other hand, it has been noticed that this grass when growing in the field is frequently covered with a moist, sticky substance, which there is reason to believe is caused by moisture absorbed from the air by the salts, but only in sufficient quantity to partially dissolve them, making a paste or gummy mixture. So that it is not so improbable that calcium chloride is sometimes formed and is to be found as such on the living plant.

SELECTIVE ABSORPTION OF SOIL CONSTITUENTS.

Another point brought out very strikingly by an examination of the analyses is the relatively large amounts of both calcium and potassium found in the leachings from the plants, when the proportion of these elements in the water-soluble portion of the soil is considered. These facts might possibly find an explanation in part in the lesser solubility of the calcium and potassium salts of the organic acid and the accumulation of such salts formed by contact of dust from the soil with the acid. But such reasoning does not afford an explanation of the enormously increased ratio between the chlor ions and the sulph ions found in the plant leachings as compared with the ratio of these substances in the soil. The relative absorptive powers of the plant for these various constituents are probably the controlling factors.

The analytical data obtained from an examination of the *Distichlis spicata*—Samples I, II, and III—are given in Table XVI. The most striking point brought out is the very large amount of acid shown to be on Sample I, amounting for 1 gram of the air-dried material to the equivalent of 23 cubic centimeters of a twentieth normal (N/20) acid. This substance was unquestionably an organic acid and a fairly strong one. It did not appear to act on crystals of calcite very readily. This might have been due, however, to the formation of a slightly soluble lime salt, which would protect the calcite from the solvent. The acid very readily decomposed the alkali carbonates and neutralized not only ammonium hydrate but potassium or sodium hydroxide in the presence of cochineal or phenolphthalein as indicator. It will be seen by referring to the analytical figures that a large amount of sodium is left after balancing the acids by the bases found. This would seem to find its readiest explanation in supposing that there was a much greater quantity of the organic acid on the plant than indicated by the equivalent of 23 cubic centimeters of twentieth normal acid, but present in the form of the sodium or other salts. By referring to the analysis (Table XVII) of the soil from which this Sample I of *Distichlis spicata* was taken, it will be seen that there was relatively a very large amount of soluble carbonates present, about 2 per cent of the soil being composed of these substances—an amount which would absolutely prohibit the growth of any ordinary plant, even though much of the salt was in the form of bicarbonate. Much of this material probably came in contact with the grass leaves, in the form of dust or otherwise, with the result that the acid decomposed the carbonates with the formation of salts of the organic acid. These same views seem to hold for Samples II and III as well, but to a lesser extent, as is shown by the quantitative measurements given.

It would appear from what could be learned in the field that this grass, in the locality from which Samples II and III were taken, often carries as much of the acid material as Sample I shows, or even more. Unfortunately for this investigation the most favorable season for securing samples had passed before Samples II and III were gathered and sent in. This subject will receive more careful attention during another field season.

ISOLATION AND IDENTIFICATION OF ACID EXUDATION.

Careful attempts were made to isolate or at least to identify this organic acid, but the attempts proved unavailing for several reasons. But very little material was at command when the investigation was taken up. The relatively large amounts of inorganic salts obtained in the water extracts could not be well separated and presented great analytical difficulties in the attempts to isolate so small a quantity of the acid as was at our disposal. Attempts to crystallize the material from solution, either as the acid itself or as a salt, proved disastrous

on account of the rapid and abundant growth of fungi in the solution when evaporation of the solvent at ordinary temperatures was attempted. The solutions of the material failed to give any reactions by which it could be identified as one of the simpler and better-known organic acids. For these reasons efforts to identify it were abandoned temporarily and further work on it postponed until a time when a larger amount of the material could be obtained. It is confidently believed that the experience thus far gained will insure a successful issue to the next attempt in this direction.

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SELECTIVE ABSORPTION OF SOIL CONSTITUENTS.

Another point brought out very strikingly by an examination of the analyses is the relatively large amounts of both calcium and potassium found in the leachings from the plants, when the proportion of these elements in the water-soluble portion of the soil is considered. These facts might possibly find an explanation in part in the lesser solubility of the calcium and potassium salts of the organic acid and the accumulation of such salts formed by contact of dust from the soil with the acid. But such reasoning does not afford an explanation of the enormously increased ratio between the chlor ions and the sulph ions found in the plant leachings as compared with the ratio of these substances in the soil. The relative absorptive powers of the plant for these various constituents are probably the controlling factors.

It would seem desirable to give earnest attention to this subject with plants grown under careful supervision in the field or laboratory, as the evidence here presented indicates that the removal or cropping of these plants for any purpose would result in taking from the soil enormous quantities of desirable plant food and the consequent raising of the proportion of undesirable elements in the soil.

FUNCTION OF THE ACID EXUDATION.

When the large amounts of soluble carbonates found in the soils upon which these plants grow are considered, and when the disastrous corrosive action of this substance is remembered, the production of the strong organic acid by the plant seems a wise protective measure of nature. The tendency of sodium carbonate to outstrip other salts in accumulating in the very top layers or crusts of a soil and there corroding the root crowns of plants has been frequently noted by all investigators of alkali problems. It would seem that this organic acid is produced by the plant in the manner most favorable to its being brought into contact with the surface sodium carbonate, partly converting this latter to the sodium salt of the acid and partly, in all probability, to sodium bicarbonate, which, there is strong reason for believing, is not itself so harmful to plant growth as the normal carbonate.[1]

PHOSPHORUS IN THE PLANT.

In the attempts to identify the organic acid on Sample I, *Distichlis spicata*, some leachings were obtained which contained a small amount of organic matter mechanically suspended, as well as some in solution. They were allowed to stand for several days in an Erlenmeyer flask, the mouth of which was covered with an inverted beaker. A rapid and voluminous growth of fungi was observed. On filtering off a small portion of the solution after it had been standing a day or two a decided though small amount of phosphoric acid was shown to be present. No trace of this substance was found in freshly prepared leachings of the plant. It would seem probable that it was formed as a result of the action of organisms either upon dissolved organic

[1] The especially pernicious effect on plants of carbonate of sodium is in all probability due to the fact that this salt readily hydrolizes in water with the formation of considerable amounts of sodium hydroxide, and it i this latter substance which is in reality responsible for its great destructive power. Sodium bicarbonate or hydrogen carbonate, $Na\text{-}HCO_3$, might be expected to hydrolize to some extent also, being composed of a strong base in combination with a weak acid; this would be equivalent to a partial inversion to the normal carbonate. But in the presence of so much carbon dioxide as is present in soils this inversion to the normal carbonate would be greatly retarded or altogether prevented. The normal dissociation of the hydrogen carbonate would then be very small indeed and any chemical activity of the compound depending on the formation of ions would be correspondingly small.

matter in the leachings or perhaps upon the organic matter mechanically suspended in the solution. From lack of material it was not possible to determine the amount of phosphorus in the plant, but the qualitative observations cited would indicate that it was present in considerable amount. It should be observed that it was a constituent of the readily water-soluble portion of the soil from which the plant was taken in very small amounts, if, indeed, it were present at all. Attempts to detect it by the phosphomolybdate method failed to show a trace. The remarkable ability of this plant to take from the soil solutions the mineral constituents it needed, in the presence of the enormous excess of other readily soluble substances, is brought out very strikingly in this connection.

For the reasons here presented it would seem that this plant is worthy of the serious consideration of the botanist and physiologist, and is undoubtedly of very great economic importance.

ASH ANALYSES.

Ash analyses of all the plants considered in this paper were made, in the hope that some conclusions might be drawn as to the inorganic materials in the plants themselves, and as to how much, relatively, was capable of being removed by leaching. These analyses will not, however, be presented, for it is obvious that they have no value whatever for the purposes here indicated. The mixture of salts on the plants was so large in amount, and fused at so low a temperature, that it quickly coated the organic matter, so that it was necessary to heat to a very high temperature and thoroughly stir the mixture to obtain anything like a thorough combustion of the organic material. This resulted in a very great loss of the salts by volatilization, sodium chloride and potassium chloride being especially important in this connection. Further, the burning of either sulphates or chlorides of the alkalies with organic materials necessarily means the more or less complete volatilization of the sulphur and chlorine, respectively, and the formation of the corresponding alkali carbonates, a point often overlooked in the consideration of ash analyses. As a consequence of these factors, the results obtained would certainly be misleading. It would appear, from the analyses of the ashes of the plants we are considering, that much more of these soluble mineral constituents can be leached from the plants than the plants ever contained, which is an obvious absurdity. For this reason it does not seem worth while to give these ash analyses any further consideration.

SUAEDA INTERMEDIA AND ATRIPLEX BRACTEOSA.

TABLE XVIII.—*Suaeda intermedia.*

	Sample IV—Stems.		Sample V—Leaves.	
Grams of substance	7.61		14.35	
Cubic centimeters of leachings	750		750	
Percentage (mineral matter) leached out	14.73		23.80	
Cubic centimeters N/20 acid, equivalent to 1 gram substance	.84		2.67	
	Percentage distribution.	Percentage in air-dried substance.	Percentage distribution.	Percentage in air-dried substance.
Ca	0.48	0.071	0.15	0.036
Mg	.75	.111	.72	.170
Na	42.36	6.239	56.18	13.375
K	7.20	1.060	4.52	1.075
SO_4	1.43	.211	.87	.206
Cl	47.78	7.038	37.56	8.938
	100.00	14.730	100.00	23.800
$CaSO_4$	1.62	.239	.51	.121
$CaCl_2$	.00	.000	.00	.000
$MgCl_2$	2.66	.392	2.35	.559
$MgSO_4$	.35	.057	.64	.152
KCl	13.71	2.015	8.61	2.049
NaCl	64.84	9.551	52.33	12.456
Na	16.82	2.476	35.56	8.463
	100.00	14.730	100.00	23.800

TABLE XIX.—*Atriplex bracteosa.*

	Sample VI—Stems.		Sample VII—Leaves.	
Grams of substance	21.49		17.79	
Cubic centimeters of leachings	750		750	
Percentage (mineral matter) leached out	4.48		10.24	
Cubic centimeters N/20 acid, equivalent to 1 gram substance	1.19		3.61	
	Percentage distribution.	Percentage in air-dried substance.	Percentage distribution.	Percentage in air-dried substance.
Ca	2.32	0.104	0.39	0.040
Mg	2.05	.092	3.36	.344
Na	37.79	1.693	41.30	4.229
K	7.90	.354	5.39	.552
SO_4	4.10	.184	6.60	.676
Cl	45.84	2.053	42.96	4.399
	100.00	4.480	100.00	10.240
$CaSO_4$	5.80	.260	1.33	.136
$CaCl_2$	1.74	.078	.00	.000
$MgCl_2$	8.03	.360	7.57	.775
$MgSO_4$	.00	.000	7.08	.725
KCl	15.03	.673	10.27	1.052
NaCl	52.18	2.338	53.56	5.485
Na	17.22	.771	20.19	2.067
	100.00	4.480	100.00	10.240

In Tables XVIII and XIX are found the data obtained from an examination of the *Suaeda intermedia* and *Atriplex bracteosa*, respec-

U. S. DEPARTMENT OF AGRICULTURE.

Report No. 72.

PROGRESS

OF THE

BEET-SUGAR INDUSTRY

IN

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IN

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1902.

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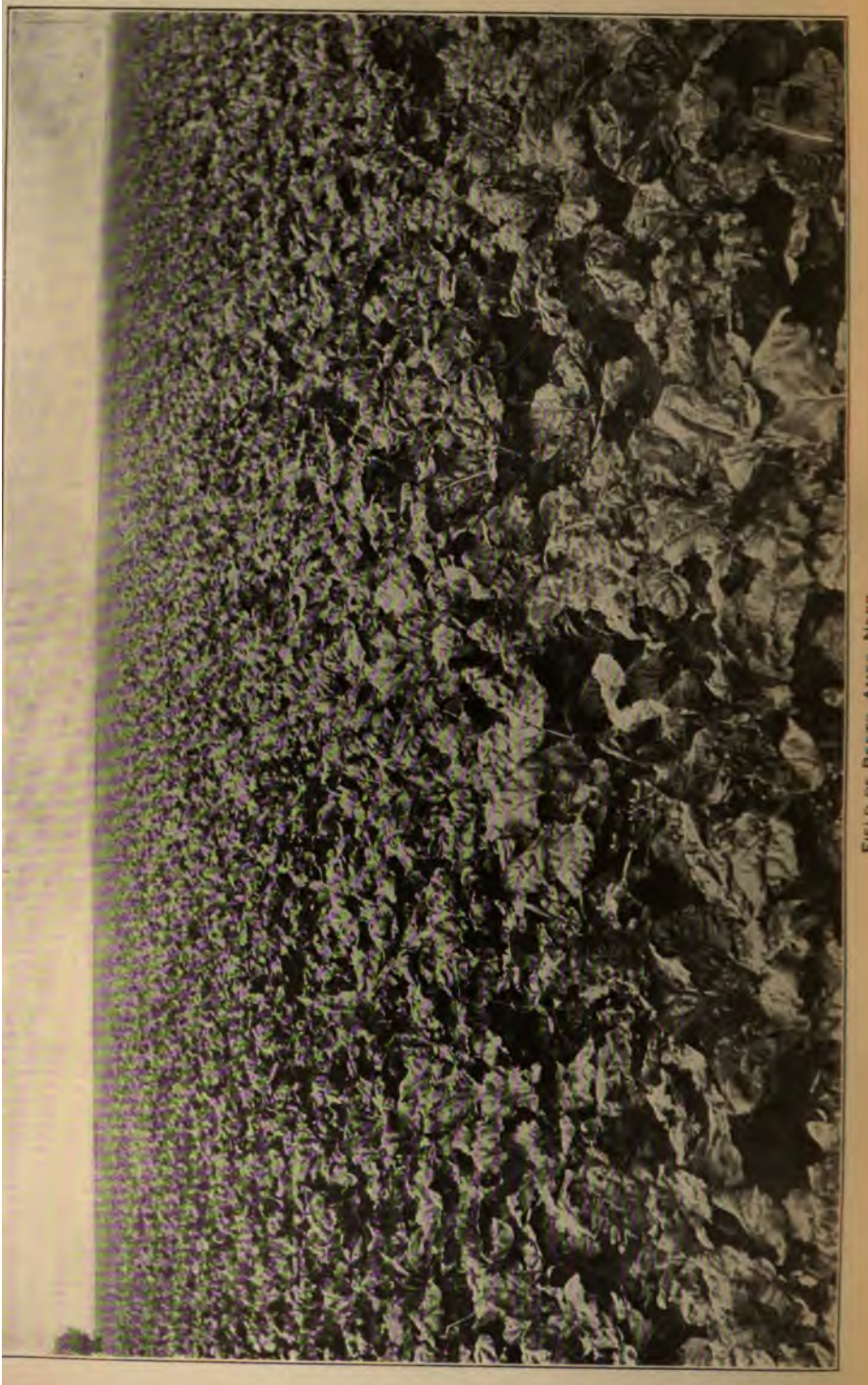

FIELD OF BEETS, AMES, NEBR.

U. S. DEPARTMENT OF AGRICULTURE.

Report No. 72.

PROGRESS

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1902.

Congress having failed to authorize the printing of an edition of this publication (known as Senate Document No. 316, Fifty-seventh Congress, first session), 5,000 copies were ordered by the Department for its own use.

MESSAGE

FROM THE

PRESIDENT OF THE UNITED STATES,

TRANSMITTING

A COMMUNICATION FROM THE SECRETARY OF AGRICULTURE COVERING A REPORT ON THE PROGRESS OF THE BEET-SUGAR INDUSTRY IN THE UNITED STATES DURING THE YEAR 1901; ALSO THE RECOMMENDATION OF THE SECRETARY THAT 10,000 COPIES BE PRINTED FOR THE USE OF THE DEPARTMENT.

APRIL 24, 1902.—Read; referred to the Committee on Printing and ordered to be printed.

To the Senate and House of Representatives:

I transmit herewith, for the information of the Congress, a communication from the Secretary of Agriculture, covering a report on the Progress of the Beet-Sugar Industry in the United States during the year 1901.

Your attention is invited to the recommendation of the Secretary of Agriculture that 10,000 copies of the report be printed for the use of the Department, in addition to such number as may be desired for the use of the Senate and House of Representatives.

THEODORE ROOSEVELT.

WHITE HOUSE, *April 23, 1902.*

LETTER OF TRANSMITTAL.

DEPARTMENT OF AGRICULTURE,
OFFICE OF THE SECRETARY,
Washington, D. C., March 26, 1902.

MR. PRESIDENT: I have the honor to transmit, for your information and that of the Congress of the United States, a report on the Progress of the Beet-Sugar Industry for 1901.

This report is composed of two parts, the first prepared by Charles F. Saylor, special agent of this Department, and the second in the Bureau of Plant Industry.

In the first part Mr. Saylor reports the operations of the various beet-sugar factories, outlines the proper methods for use in growing beets, and presents a mass of pertinent statistical information.

In the second part are presented (1) a discussion of the insect enemies and fungous diseases attacking sugar beets, and the methods of combating the same; and (2) a report on the production of sugar-beet seed, a branch of the industry which is now receiving some attention in this country.

From a careful study of the report and observation in the field, I am satisfied that the future of the beet-sugar industry depends more upon correct farming than any other one consideration. The tonnage reported is 9.6 per acre, but this can be greatly increased by a proper system of crop rotation (to keep the soil supplied with organic matter), thorough cultivation, and fertilizing where necessary.

A weak place in the industry is the lack of a proper disposal of the by-products of the factories, the value of which is not sufficiently appreciated by our people. It has been ascertained in all European countries where the industry is well established, that the pulp, after the sugar is extracted, is valuable for feeding to all domestic animals. Our people are learning this, and when it is fully comprehended this crop will be grown by farmers with a view to using this by-product to take the place of other mill feeds on the farm.

In view of the importance of the subject, I have the honor to recom-

mend that at least 10,000 copies of this report be printed for the use of this Department, in addition to the number which Congress may in its wisdom order for the use of the members thereof.

I have the honor to remain, Mr. President,

Very respectfully,

JAMES WILSON,
Secretary.

The PRESIDENT,
White House.

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PROGRESS OF THE BEET-SUGAR INDUSTRY IN THE UNITED STATES IN 1901.

REPORT OF SPECIAL AGENT,

CHARLES F. SAYLOR

LETTER OF SUBMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
OFFICE OF THE SPECIAL AGENT,
Washington, D. C., March 17, 1902.

SIR: I submit herewith, for your inspection and approval, my report for 1901 as special agent for the investigation of the sugar industry. It includes the results of my own observations and investigations, and a considerable mass of information pertinent to the subject collected from various reliable sources.

CHARLES F. SAYLOR,
Special Agent.

Hon. JAMES WILSON,
Secretary of Agriculture.

INTRODUCTION.

In reporting the progress made in the development of the beet-sugar industry for 1901, I wish to call attention especially to the continued and rapidly increasing interest in the subject among all classes of people. Everything considered, this public interest and the rapidity with which the industry itself is assuming substantial form is remarkable. It is not confined to any particular section of the sugar-beet area, but appears to be about as definitely appreciated and understood in one as another. In some States circumstances have led to prompter action in establishing the industry; at the same time every available part of this area is being carefully tested and studied preparatory to definite future action. When agitation as to the future of the sugar market shall have ceased by definite settlement of the questions involved, the progress of the beet-sugar industry in the United States will be more stable and progressive.

To illustrate the development of the industry the State of Michigan may be cited. That State will have 17 factories in operation during the campaign of 1902, a result accomplished in the space of four years. The thing that made Michigan a peculiarly favorable field for the introduction of this industry was the fact that it could be built up on the foundations of another—the lumber industry, which is waning. There are 30 more projects under consideration and probably more factories will be built in the near future.

When Utah began to manufacture sugar from beets it was found necessary to produce them by irrigation, like other agricultural crops, and here the problem of raising beets by irrigation was worked out. Fortunately the experiment was tried under favorable conditions. No other country was able to furnish us any definite facts bearing on this subject. The results of these experiments in Utah were of vital interest to the people of the whole arid region. In many sections the people profited by the results of Utah's experience, and the arid region, through sugar-beet culture and its benefits, assumed a greatly increased importance. It must be regarded as an important factor in the future, not only in the production of sugar, but in general agriculture.

LOWERING THE COST OF SUGAR PRODUCTION.

We are gradually emerging from the experimental stage of sugar-beet growing. Some very valuable deductions can be made from a study of this experimental period. American methods in general agriculture are studied by all other countries. They represent the best. But in the cultivation of sugar beets Americans have been the students of the methods in vogue in foreign countries. These methods we have been applying. Meanwhile we have been studying the results and gradually developing methods of our own. Our experience has carried us into fields hitherto undeveloped—for instance, the growing of sugar beets by irrigation. We have also depended largely on the natural fertility of the soil, while Europe must resort to expensive fertilization.

The United States present so many different kinds of agricultural conditions that a fund of information based on experience was necessary. In growing sugar beets we started with set theories and fixed rules for all cases regardless of varying conditions, but we have found that specific rules can not be given general application. Methods suited to conditions had to be developed through experience, and the same is true of beet growing in other countries, as will be seen by a study of the development of the industry in Germany.

In 1878 the German beets averaged 9.24 per cent sugar content. Their beets gradually improved from year to year until, after twenty years, the average sugar content of the German beets in 1898 was

13.15 per cent. This was a remarkable improvement, the increase for the period being 3.91 per cent. This was doubly important from the fact that, not only did the factory get 42.31 per cent more sugar at the close of the period, but they secured beets from which it cost a great deal less to extract the sugar. In twenty years Germany decreased her cost of production of sugar over one-half, and it is this future prospect that gives the beet-sugar industry in this country a standing. We must have the experience, and we must have the opportunity to get it. We can feel assured that when we do get it the cost of production will be a great deal less than it is to-day. This can not be brought about simply by taking the experience of the foreigner and applying it, but it must be accomplished by studying proper systems of cultivation under our own conditions. It is also definitely settled that we can not take the methods used in one section or State and apply them in some other section or State. Even in different sections of the arid region radically different methods must be applied.

We should eventually manufacture at least sugar enough to supply our own needs. In order that it shall have the sympathy of the public, it must be made clear that some time in the future this industry will stand on its own merits and be able to meet the competition of other sugar-producing countries.

The cost of producing sugar, as shown by the last census report on this subject, was such that the manufacturers of sugar, taking the average of all the factories, made but a small margin above the cost of production. If the wear and tear of the machinery had been taken into consideration, they would have been making sugar at a slight loss. There is, however, a tendency towards a lower cost of production in this country the same as has occurred in all other beet-sugar producing countries. Some of our older factories are now producing sugar for three-fourths of this average cost. It is not because they have any better natural advantages, and it is not reasonable to suppose that this difference in cost of production will be permanent. The only apparent reason for their lower cost of production is experience. In ten years, these older factories have reduced their cost of production from 25 to 33⅓ per cent. In the years to come a very considerable reduction may be looked for and the other factories coming into operation will have reached a cost of production at least as favorable as that of the original factories now is.

COST AND PROFITS OF BEET PRODUCTION.

It costs about $30 per acre to produce sugar beets and to market the crop where rain conditions prevail. This is without taking into consideration the rent of the land, but it includes the farmer's time and everything else that enters into the cost of production. Accord-

ing to the table on page 36 the average yield of sugar beets for 1901 was 9.6 tons per acre. Abundant evidence exists, however, to show that this is exceptionally low, and that adequate care and suitable methods of cultivation promise a very much higher average of yield. In making the following calculations I have taken as a basis an average yield of 12 tons per acre. The experience of all careful growers will show this estimated average to be under rather than over the mark. The cost of production will decrease gradually because of improvements in implements and methods. The beets grown have a gross value at the factories of $4 to $4.50 per ton (in States paying no bounty). This gives a gross return per acre of $48 to $54, and a net profit of $18 to $24. It must be kept in mind that these are averages of gross and net proceeds. It is never very encouraging to consult the average of agricultural crop statistics; indeed, it is often said that "the average crop does not pay." If one should take the figures of the average crop of corn in Iowa, for instance, or the average crop of wheat in Minnesota or Kansas, and compute the proceeds at the average market price and deduct therefrom the cost of production, the results would show a very small remuneration or an actual loss quite discouraging to one who has not investigated this subject.

Taking what seems to be the most authentic figures, the cost of producing sugar beets in sections where they are grown by irrigation is about $40 per acre. An average of 13 tons per acre can be produced having a higher sugar content and worth $4.50 to $5 per ton, making the gross proceeds $58.50 to $65 and the net profit $18.50 to $25 per acre. These figures give to the farmer in each case a profit greatly more satisfactory than in the case of other crops. But the successful farmer will never be satisfied with the average proceeds of any crop, and it is to him we must look for the results that give the more encouraging inducements to beet culture. Many growers receive as high as $75, and some as high as $100, per acre for their beets, these high results depending upon the superior quality of the land and the superior skill of the one producing the beets. If a farmer has poor land or is a poor farmer, he is not in a position to expect much in planting any kind of crop. These statements are sufficient to give a farmer who is experienced in all other kinds of crops a fair insight into the situation.

THE SUGAR-BEET BELT.

Experience throughout the United States has demonstrated that sugar beets do best in localities having certain climatic conditions. Up to date a large strip of land reaching across the northern portion of our country has given the most satisfactory results in growing sugar beets. It starts at the Hudson, takes in the southern half of New York, the northern portions of Pennsylvania, Ohio, Indiana,

Illinois, Iowa, and Nebraska, the southern half of Michigan, Wisconsin, and Minnesota, all of South Dakota, large sections of Colorado, Utah, Wyoming, Montana, Idaho, Washington, Oregon, and the coast side of California.

The mapping out of this belt is based on temperature conditions only. Throughout large areas included in the belt other conditions make the growing of sugar beets either impossible or unprofitable. But there are many districts where this industry succeeds. The actual location of such can only be determined by experiment. It would be impossible to locate them on a map at present, as many of them are as yet undetermined. By consulting the published experimental results in bulletins of the State experiment stations and the reports that have been issued by the Department of Agriculture, much accurate information can be obtained with reference to many of these lands. There are valleys in the arid regions of the Rocky Mountains having the right conditions, with sufficient water supply for irrigation, that have reached results never before equaled with sugar beets, even in countries that have been working with the industry for a half century.

The State agricultural experiment stations have done much pioneer work in determining whether the prevalent conditions in their respective States are favorable or unfavorable to the beet-sugar industry. The Department of Agriculture has given considerable attention to this problem. It has cooperated with the State experiment stations so far as feasible; has pursued independent investigations wherever practicable, and has published the results in reports and bulletins. Results are given by counties and States, and show averages of quality and purity of sugar beets grown. These results have been placed in comparison with the results arrived at by the experiment stations. This work has been repeated year after year, so that the public might discern the extreme either of favorable or unfavorable years, and estimate the effects of normal conditions in normal years.

INCIDENTAL BENEFITS AND BY-PRODUCTS.

In this modern and scientific age nothing should be allowed to go to waste, and the question of by-products is an important feature of every industry. It is a question of special importance in view of the high cost of production incidental to the superior standard of living prevalent in this country. Besides the important matter of by-products, due consideration must also be given to the incidental benefits resulting from the growth of sugar beets.

IMPROVEMENT OF LAND AND FARMING.

The high cultivation that must be given the land through deep plowing, thorough harrowing, and constant weeding and cultivating finally makes the land of superior quality for any purpose. It will grow

better corn or wheat, and at a less expense, on account of the absence of weeds and grass. Finally, through rotation, other fields are brought under this high state of cultivation, until the whole farm is at its best condition of soil fertility and productiveness.

In the study of beet farming in Germany and France it is interesting to note the progress that has been made in general agriculture through sugar-beet growing. A great many intelligent Americans have gone to Germany and France to inform themselves on this subject. There a farm is blocked off into a series of divisions, corresponding to the crops that are grown in rotation. This rotation is settled for several years in advance and is followed very strictly. Sugar beets are grown on certain fields one year, followed by other crops in the series, to be followed again by sugar beets in their proper place in the rotation.

By their system of fertilization the fertility of their soils has not only been maintained, but they have been made to increase in productiveness. These results are brought about partially by cultivation. The deep plowing and constant cultivation with the plow and hoe naturally keep the soil in the finest condition. What is true of these older countries will be true of our country in the end. Improvement of the land is a factor that we must not lose sight of in considering the benefits of the beet-sugar industry of this country.

The difficulties of growing sugar beets are so many, and to the factories the success of the growers means so much, that it is the custom of each factory to have a farm superintendent. In Europe more stress is put upon the work of this officer than almost any other one connected with the sugar company. He is not only required to be trained by long practical experience in agriculture, but he must be a thorough scientist. He is paid a salary commensurate with his importance. A farm superintendent is employed also in American factories. We have not as yet gone so far in the requirement of scientific training, but the tendency is growing strongly in this direction. When contracts are made with the farmers, a clause is inserted requiring beets to be grown as the farm superintendent directs. Either he or his assistant visits the farms repeatedly, offering the farmers instructions on how to prepare the ground, how to cultivate, and how to do all other necessary work in growing beets successfully. He gives advice to the farmers in regard to meeting contingencies; decides when the beets are ripe, and issues the orders directing the farmers to deliver their beets to the factory. His work is a very vital part of the business. He is a constant stimulator to agricultural improvement on the part of the farmers in the neighborhood, and especially to the farmers under his direction. The benefits of this official's instruction and influence to a farming community can hardly be measured in dollars and cents. His influence is not limited to the present but extends to the future. He is one of the important factors in settling what will be the final status

of the industry. It is a very fortunate incident that the work of a sugar factory should bring a farming community under the influence of such trained supervision. It brings a community growing sugar beets under a systematic rotation of crops properly arranged. It gives an intelligent knowledge of the application of fertilizers, and applies the proper scientific methods of cultivation.

BEET PULP.

In all my reports I have aimed to emphasize the value of this by-product. I regard it as a feature not to be overshadowed even by the main product, sugar. After the sugar has been extracted from the cossettes or slices, and after the water has been pressed out and the pulp deposited in the silo, it represents about 45 to 50 per cent in weight of the beets that originally produced it. In the beet-sugar producing countries of Europe this pulp is thoroughly appreciated and understood. Some of it is sold to the farmers and the dairymen fresh from the press. The rest of it is dried and pressed and sells on the market at about $2 per hundredweight, very much as does our oil cake, being purchased for feeding to all kinds of stock.

Pulp as a by-product is of especial value in our own country with its stock and dairy interests. Its value is not to be measured alone by the actual money received for it, but also by the opportunity and encouragement it offers to dairying, stock breeding, and stock feeding. The people of this country have been slow to appreciate the usefulness of pulp. The older factories whose operations date back a decade have not yet been able to dispose of their pulp at its real value. At first new factories usually have to pay for the removal of the pulp in order to get it out of the way. Farmers gradually begin to use it, and stockmen and dairymen test it. After a time factories are able to dispose of the pulp at some figure; but eventually they will be able to dispose of it, as is done in Europe, for what it is actually worth.

The State of New York has large dairy interests. The farmers of this section are accustomed to feeding by-products from the distilleries, breweries, and starch works. When the sugar factories were established in that State pulp feeding came as a matter of course, and those factories were able to dispose of their pulp in the beginning at a higher figure than were the older factories that had been manufacturing sugar from ten to twelve years. Finally all of this pulp will be sought and paid for at its true value the same as other feeds. When that time comes the sugar interests will be greatly benefited.

I made my original investigation of pulp feeding at one of the older factories—the one at Grand Island., Nebr. This factory was unable to interest the farmers in the use of pulp for feeding purposes. A cattle company had investigated the benefits of feeding pulp, and had built at the factory stock pens and yards under the management of Mr.

John I. Riemers, of that city. The bulk of the pulp was unused, being hauled out with a road scraper and dumped on the prairie. When I was there an accumulation including the pulp of four years was lying on the prairie. Mr. Riemers' feeder was using the four-year-old pulp in preference to any of the rest.

During the sugar campaign of 1901, I was at Norfolk, Nebr., where is located one of the factories owned by the American Beet Sugar Company, which also owns the Grand Island enterprise. The factory at Grand Island did not operate last year, but all beets were shipped to Norfolk. This company has an arrangement with the farmers in Nebraska by which the beet growers can secure all their pulp for nothing, provided they want to feed it or use it themselves, but they can not dispose of it to some one else. The company offers the pulp as a sort of premium to beet growers. I was surprised and gratified to learn that some of the farmers from Grand Island were claiming their pulp at Norfolk and having it shipped back by carloads at a cost of at least 25 per cent of the original price they got for their beets.

BEET LEAVES.

When the beets are harvested the crowns with the adhering leaves are cleaved from the beets with a sharp knife and allowed to fall on the ground. It is the aim of the person doing this work to cleave the crowns at the line made by the sun, indicating where the beets have projected above the ground. Sometimes a beet projects but little and sometimes a great deal. The amount of the crown cut off depends upon this. I believe it is the best practice among the beet growers to allow these tops and crowns to remain on the ground and be plowed under for fertilizer. In many instances, however, they are gathered up, stored, and fed. In others, stock is turned into the field and allowed to feed upon them as they lie on the ground. Occasionally they are loaded on wagons and hauled to the villages, towns, and cities, and sold for forage the same as hay or other feed.

There can be no doubt about the value of beet tops and beet leaves as feed for stock, nor can there be any doubt as to the importance of keeping up the fertility of the soil by allowing them to remain on the ground. If they are taken off, then fertilizer of some other kind must be used instead. It is simply a question which is the best way to do it.

SIRUP MANUFACTURE.

With the production of sugar from beets in the United States has come also the manufacture of sirup for table use, for fruit preserving, and for other purposes. This production is the result of an investigation of this subject by parties living in this country.

One factory is using this sirup in the manufacturing of apple butter,

blackberry, raspberry, strawberry, and currant jams, and in the preparation of mincemeat and other articles in which sirup and sugar may be used.

MOLASSES.

The factories of this country are able to make from sugar beets an amount of white granulated sugar equal to from 9 to 12 per cent of the weight of the beets, the amount depending on the sugar content and purity of the beets and the effectiveness of the process. The beets themselves may have contained originally from 12 to 18 per cent of their weight in sugar. Excepting a small percentage which goes off with the pulp, the balance remains in the molasses. No process has ever been devised to extract all this sugar, nor have any satisfactory results ever been secured in dealing with the molasses by-product itself. It is one of the things that has always given the manufacturer of beet sugar trouble. It has an acrid taste. It has been impossible to use beet sugar in the raw or unrefined state on account of the salts of different kinds extracted from the beets along with the sugar. It is necessary to eliminate these salts by a process of refining before the sugar can be used. These salts appear in the molasses in a condensed form, rendering this by-product absolutely useless except as worked up into shoe blacking, vinegar, alcohol, etc. Scientists have been endeavoring since the beginning of the beet-sugar industry to find some way in which these salts may be eliminated, and the sugar contained in the molasses secured, or the molasses converted into pure palatable sirup. The presence of the salts has always thwarted their efforts to extract this sugar.

This molasses can be used in the manufacture of alcohol, but the revenue taxes are so heavy that this has not been undertaken. Good vinegar can be made from molasses, but this is a separate business from sugar making and requires separate organization; it has not been undertaken on any extensive scale as yet. There are a great many uses to which this molasses could be put, providing a business was established to work upon it as raw material. The principal use that is now made of it is to mix it with leaves or pulp for feeding purposes. It is also used to some extent as a fertilizer.

BENEFITS TO OTHER INDUSTRIES.

The establishment of a sugar factory not only opens up a large field for the employment of labor, but it opens up a field for the employment of capital. It becomes at once a market for considerable crude material to be used in conducting the business. First and most important, it furnishes a market for the beets. Then the factory is a large consumer of coal, and, as the factories are often established in communities having local coal fields, they become at once local mar-

kets for a local product. The amount of coal necessary to work up a certain amount of beets is generally computed at about 17 per cent by weight, or in case of an ordinary factory of 350 tons capacity, about 60 tons of coal per day, or 6,000 tons for a full campaign of one hundred days. A factory also consumes a large amount of lime rock. Of necessity this must also be a local product. A factory usually consumes lime rock to the extent of about 10 per cent of the crude weight of beets worked, which, in the case of a 350-ton factory would be 35 tons of lime rock per day, or 3,500 tons for the campaign. It consumes about one-fifth as much coke as lime, or a little less than 700 tons during a campaign.

The establishment of a factory in a community necessitates considerable transportation of crude products, beets, coal, and lime rock, to the factory, and of the finished product to the market. It stimulates banking and almost all kinds of mercantile business throughout the community.

AGRICULTURAL PROBLEMS.

There are two sides to the proposition of establishing a sugar factory in any particular community: First, that of the farmer involving agricultural conditions; and, second, that of the manufacturer, or those financially interested in the enterprise.

The leading difficulties of the farmer may first be noticed: To begin with, he is unacquainted with the methods of cultivating the sugar-beet plant, and his first experience usually proves unsatisfactory. He is accustomed to certain methods in farming. As a rule he is conservative, and thinks, from his long experience in farming, that he knows how. He undertakes to apply the methods used in the cultivation and production of other crops. He is not inclined to listen to those who are posted in methods applicable to the new crop. Eventually he finds out his mistake. He finds that in growing sugar beets he must apply principles, in many cases, the reverse of those necessary to other crops. For instance, he has been accustomed to growing large ears of corn, large hogs, and large steers; but in the case of sugar beets he finds that the first question is not one of size, but of quality. He must grow beets of a certain size, purity, and sugar content. In order to accomplish this he must give careful attention to the work of preparing the land, planting the seed, bunching, thinning, and cultivating. He finds that attention to details counts in results at the harvest and the profits of this crop. He learns that the whole process is a very laborious and expensive one, entirely unlike anything he has attempted before. To be successful, he must apply the methods of the gardener to a field crop; he must have a rich soil and the proper rain conditions at the proper time. These facts can only be learned through experience.

FARM LABOR.

The labor problem is important in the cultivation of sugar beets. At certain stages of their growth sugar beets require a considerable amount of labor. This labor is very tiresome. As a rule the farmer, if he grows beets to any extent, does not have on his farm sufficient labor to take care of the work of thinning, bunching, hoeing, and harvesting the sugar beets; nor does any farming community possess to any considerable extent the labor necessary to grow the beets that a factory will require in a campaign. It will cost about $30 an acre in sections where sugar beets are grown under rain conditions, and about $40 to $45 an acre in sections where beets are grown by irrigation, to cover the cost of seed, preparation of seed bed, bunching and thinning, hoeing, cultivating, harvesting, and delivering to the factory. These estimates apply to growing sugar beets when it is done right. In the farming communities of foreign countries, as a rule, a large amount of suitable labor can be secured in the neighborhood, because these neighborhoods are more thickly settled, the whole population is willing to do the laborious, tedious work required, and whole families work at it, including the father, mother, and children. In this country, as a rule, the farmer, his older sons, and hired hands must attend to the outdoor work. It has been found necessary for the sugar-beet growers to resort to the cities and towns for the extra labor required. Most of this work comes about the time the public schools are closed, and boys from 12 years up are used for bunching and thinning the beets, for hoeing them during the season, and to aid in the harvesting, by piling the beets, cleaving the tops, and loading the beets into wagons. In the cities also live many foreigners from Holland, Germany, Russia, Sweden, and other countries, who are thoroughly familiar with this kind of work. These people are willing to move out into the fields and live in tents and make contracts at so much per acre for bunching, thinning, hoeing, weeding, and harvesting. Since the starting of the beet-sugar industry in this country many other foreigners are coming here, knowing that they can secure employment of this kind. While the labor question is a serious one, it is one capable of solution.

SEED PRODUCTION.

At present most of the seed used in this country for growing sugar beets is imported from Europe. It is quite an item in the expense of production. The rule is to plant 20 pounds per acre, the factory furnishing the seed. It costs the farmer 15 cents per pound, or $3 per acre. It would seem that this country should not only produce its sugar but the seed for growing the beets.

Seed growing is a very intricate business, and to be successfully

done it requires considerable capital and a great deal of care and skill. For this reason beet-seed production in this country is in its infancy, and only a very small proportion of the seed used is produced here.

Some of the factories are starting seed production in connection with sugar production. The factory at Lehi, Utah, has probably accomplished the most in this direction, but something has been done at Watsonville, Cal., and Rockyford, Colo. I believe some of the factories in Michigan are also starting up this work.

METHODS.

Every year the scientific agricultural superintendents for each factory settle certain problems that will have much to do with lowering the cost of beet-sugar production in the future for that particular locality. In this connection may be mentioned some interesting observations I have made during the past year. It is a well-settled conclusion of the beet growers at Leavitt (formerly Ames), Nebr., that land on which corn has been grown the previous year is the best for a beet field. They consider that the cultivation given the corn during its growth has much to do with the growing of sugar beets the following year. In order to plant the beets on corn ground, all stalks and roots must first be removed. This work is quite expensive. The factory at Leavitt has been in operation for three years and it has taken that time to work out this simple problem. The original plan was to plow the ground shallow at first, then go over it with a steel-spring hay rake and collect the stubs and stalks and burn them. What the rake did not secure, laborers had to gather by hand. It has been estimated that it cost about $3 per acre to accomplish this work. On the farms growing beets for this particular company, the Standard Cattle Company raises its corn, hay, and other forage for feeding purposes. Most of the corn is cut up for fodder. After three years' experience it has been found that they can go over the corn ground with a disk plow in the spring when the frost begins to go out of the ground, and so thoroughly tear up the roots of the stubs that they can readily be turned under out of the way by deep plowing, and that this can be done at 75 cents per acre, reducing the cost of this work 75 per cent.

I was interested in investigating some of the methods used at Rockyford, Colo. At this place it was found that the beet crop does best when it follows alfalfa. In Nebraska, and most places where alfalfa grows, it is only necessary to plow the crop under. Thus the land gets the benefit of the green crop as fertilizer. But the farm superintendent at Rockyford insisted that this could not be done there because, if the alfalfa were plowed under, every joint and root would grow, and the beet field would look more like an alfalfa field than anything else. It is necessary there, before these alfalfa lands can be used for planting beets, to actually remove from the ground both the tops and roots of the alfalfa plants.

These illustrations serve to show some of the problems that have to be worked out on the farms before the best results can be reached.

IRRIGATION.

Measures are now being considered before Congress to more completely develop the irrigation resources of the nation. The supply of irrigation water is now secured almost entirely by tapping the running streams during the growing season. In the case of heavy rainfall, or when the snow melts in the mountains, much more water could be secured if stored and let down gradually through irrigating ditches when the crop needs it. At present much of this water runs to waste. The present consideration by Congress is to devise a plan by which permanent storage reservoirs may be constructed, into which may be conducted the drainage from certain watersheds. This requires a careful and complete system of engineering. If it is accomplished it will very much extend the area of land that can be utilized for growing crops, especially for sugar beets, which have shown a remarkable adaptability for growth under irrigation. When the application of irrigation shall be permanently understood, the irrigated districts will certainly be the ideal sugar-producing sections. Much has yet to be learned on this subject, but there is an opportunity for gradually decreasing the cost of production.

CONTROL OF INSECT PESTS AND FUNGOUS DISEASES.

Sugar-beet crops have already felt the effects of insect pests and diseases peculiar to the plant. Up to date we have been practically at the mercy of these enemies when their attacks occur. The Department of Agriculture and scientists of the various experimental stations throughout the country have been giving these subjects careful attention, studying like occurrences in Europe and the remedies, preventives, and methods used to meet these enemies; and eventually their efforts will no doubt be successful to a great extent.

PROBLEMS FOR THE MANUFACTURER.

The manufacturer or the capitalist who builds a factory finds that he has even more problems to work out than the farmer, and, like the farmer, he usually discovers that he is entering a field that is entirely new to him.

NECESSARY INVESTIGATIONS.

Before establishing his plant the prospective manufacturer must thoroughly investigate certain conditions: (1) The water supply. He must have an abundant supply of pure water for the use of the factory. (2) The fuel supply. The factory must be located in a section where cheap fuel can be secured. The fuel used is usually coal, but on the

Pacific coast petroleum is used to a large extent, and in some of the mountain States it is found that wood is the cheapest fuel. (3) The market for the products. (4) The matter of transportation. This should be thoroughly canvassed and settled prior to establishing the factory. The fact that it is proposed to establish a factory on a particular line of railroad can generally be used as a lever to secure, by contract, low freight rates for the future, both in shipping beets and the finished product—sugar. (5) The supply of lime. The local quarries of lime rock must be investigated to see if the quality is suitable and the supply sufficient, as a large amount will be required.

The general conditions having been found satisfactory and the factory being built, other problems arise. In the beginning only a limited amount of skilled labor is employed. Eventually every employee of the factory will become skilled in his particular part. After two or three campaigns have passed the factory has worked out the details of producing the best product at the cheapest cost with the machinery which it has. When this point shall have been reached those interested will be prepared to estimate the cost of production of beet sugar. The difference in cost of production at a new factory and at one operated for a considerable time is much greater than one unacquainted with the subject would suppose.

CRUDE MATERIALS.

Each factory must resort to the cheapest fuel available and suitable for its use. There is a vast difference in the grades of coal used by the various factories. Coal, however, is not the only fuel used. On the Pacific coast it is supplanted by petroleum, a product of southern California. At La Grande, Oreg., and to some extent at Waverly, Wash., wood is used.

Attention is directed to the tables (pp. 35–36) compiled from data furnished by the factories themselves covering the various materials used by them during the past year. The amount of coal on an average is shown to be 19.9 per cent of the amount of beets. This is a very high rate when compared with the amount of coal used in the older beet-sugar producing countries. There is an opportunity for economizing in the future.

The same tables show that, in amount of limestone used in the various factories, there is a wide difference. It is evident that some of the factories have not been able to secure the best limestone, or that they have not been able to economize in its use.

There is also quite a difference in the cost of a ton of coke to the various factories. Considerable is imported. Coke production in this country is confined largely to the East, but as new coal regions are discovered the coke industry will probably be extended, the facilities for securing this material will be improved, and it will become cheaper.

AMERICAN-MADE MACHINERY AND IMPLEMENTS.

The machinery placed in the original factories in this country was largely imported. Since that time our machine shops have taken hold of the matter, and we are now able to entirely equip a factory with American-made machinery. In addition to this, American designers have been working upon the improvement of this machinery and have done a great deal to introduce improvements for cheapening and shortening the work.

We began the industry of growing sugar beets with cumbersome implements imported from Europe. No sooner did the cultivation of this crop reach a considerable extent than did the implement dealers begin the improvement of the implements used. Much progress has been made in this direction. The objects aimed at have been to make the machinery less cumbersome, and to invent new and cheaper appliances for use in seeding, cultivating, and harvesting, so as to economize in horse power and human labor.

EDUCATION OF LABOR.

Every new factory starts with a few men educated in sugar making. Work in the factory will eventually educate all the employees. As long as the number of factories is rapidly increasing it will be necessary to employ considerable inexperienced help. When the industry shall have reached a later and fuller stage of development this necessity will largely disappear, and each factory will be operated throughout with men thoroughly posted in the work they have to do.

ATTITUDE OF THE PUBLIC.

The sugar industry, like everything else, is dependent to a considerable degree upon the sympathy manifested by the public. Beet sugar has had to meet the disadvantage of public prejudice. In the beginning the idea was quite prevalent that beet sugar was inferior to cane sugar. The term cane sugar was confused with imported sugar. People appeared to have the idea that all sugar brought into this country was made from cane, while, as a matter of fact, a large portion of it was beet sugar imported from Europe. It was not uncommon for people to call for cane sugar at the stores, or at least to insist upon paying less for the home product made from beets. If beet sugar is properly made there can be no difference. Experts find none. Yet, at the present time, home-made beet sugar is placed at a disadvantage in having to enter the market at 10 cents per hundredweight less than cane or imported sugar. As with all other prejudices, it will take time to overcome this. In this discrimination is involved not only a pecuniary loss to the beet-sugar producers, but a restriction of the market. As the industry grows, it may be confidently expected that this feeling will entirely disappear. A community of interests will operate to make home-made sugar popular.

THE QUALITY OF THE BEETS.

In the process of making sugar, what are known as the impurities in the beets operates to prevent the extraction of the sugar. It costs a great deal less to secure the sugar from a ton of beets high in purity than from a ton of beets low in purity. Not only is less sugar secured, but it costs a great deal more to secure what is obtained. As sugar-beet growing proceeds in a district, there is generally a gradual increase in the purity and sugar content of the beets, because the farmers learn to grow the crop more successfully. The cost of production is materially reduced when the farmer is able to grow a crop of good quality and high purity. Judging from the experience of other countries, we should be able, in twenty years, to produce beet sugar at one-half the present cost.

FACTORY OWNERSHIP OF LAND.

There are several projects well organized and capitalized that have plans for developing a lot of new land under new irrigating ditches, and tapping new sources of water supply. The plan is to locate several sugar factories in a series at different points along one system of irrigation. I have personally examined the plan for one project of this kind capitalized for $3,000,000, and the scheme appears perfectly feasible. This enterprise foreshadows the tendency of beet-sugar development in the arid region. In organizing such a beet-sugar enterprise the first problem for the promoters is how to secure a supply of beets. The territory is unsettled. The enterprise comprehends not only the building and equipment of a factory, but the securing of an adequate and certain supply of sugar beets. This naturally leads the promoters to conclude that the manufacturing company itself should own or control sufficient land to furnish the supply of beets. The present tendency of beet-sugar production under these circumstances involves not only the establishment of factories, but the purchase of sufficient land to furnish the raw material. This tendency is so strong, and of so much importance, that I feel the necessity of calling especial attention to it. It grows out of the natural conditions that exist. This method of procedure is directly opposite to that which obtains in the Mississippi Valley, or in the older agricultural States farther east, where the farmer furnishes the beets and the manufacturer confines himself to producing the sugar. In these sections there will always be two interests involved—one that is strictly agricultural and the other strictly manufactural. But the system of development in the arid region unites both interests in the manufacturer and eliminates the independent farmer.

EDUCATIONAL FORCES AT WORK.

There are various forces at work educating the people at large, and especially the farmers and factory people, in the production of sugar

beets and the manufacture of sugar. These forces deserve special attention, because it is through their influence that the various mistakes, leaks, and losses are eliminated and the cost of production reduced.

THE PRESS.

The press may always be considered as the advance agent of progress. It has been a very active agent in the establishment of the sugar-beet industry. No sooner does any State or section begin the preliminary investigations of this subject than writers for the public press begin to investigate and to disseminate information pertaining thereto. Many times this work is crude, but in the end it educates the press itself as well as the public. When these efforts have materialized into the actual establishment of a sugar factory, papers of another class take up the work, namely, the agricultural papers, or in some cases special papers devoting their attention to the sugar industry. Such special papers are now published in Pennsylvania, Illinois, Michigan, Colorado, and California. Papers of this class carry the work along, developing with the progress of the industry itself. Their attention is not only devoted to the farmer and everything that has to do with his side of the work, but to the work of the factory itself.

PUBLIC MEETINGS.

Another factor in the education of the people in sugar production is the convention. With the first talk of a factory the farmers are called together and the benefits of the sugar industry are outlined. Public speakers discuss the relation of the industry to the farmers and to the business elements of the community. Steps are inaugurated to test the conditions for growing sugar beets and to interest capital in establishing a factory provided the results are favorable.

The next step in the development of the convention work is the calling of a meeting, in which the various sections of a district or State are represented by local delegates, to consider the larger questions involved. Experts versed in the agricultural side of the problem and others versed in the factory side address these meetings, and in this way a general interest in the sugar industry is aroused. The convention idea develops from the local to the general.

ACTUAL EXPERIENCE.

When a factory has been established actual experience in raising beets and making sugar completes the education of all concerned. The work becomes practical as well as theoretical. Farmers learn exactly what it costs to grow sugar beets. They learn about the production of the crop, the labor involved, the profits obtained, and the incidental benefits in the improvement of land, stock feeding, and the like. Manufacturers know what they can accomplish in the pro-

duction of sugar, the cost and the profits of the sugar factory. Business men discover what their relations are to the industry and the laborer learns its resources of employment. The coal dealers, quarrymen, transportation companies, coke dealers, and furnishers of all kinds of supplies for the factory are advised of their status in this new industry.

BEET-SUGAR FACTORIES OF THE UNITED STATES.

The recent census shows the rapid growth of the beet-sugar industry in this country. Thirty-one factories had been established before the end of the century. Since that time eleven other factories have been put in operation, located at the following places, and having the daily capacities named: Lyons, N. Y., 600 tons; Loveland, Colo., 1,000 tons; Rockyford, Colo., 1,000 tons; Sugar City, Colo., 500 tons; Bingham Canyon, Utah, 350 tons; Provo, Utah, 350 tons; Logan, Colo., 400 tons; Lansing, Mich., 600 tons; Saginaw, Mich., 600 tons; Salzburg, Mich., 400 tons; Menomonee Falls, Wis., 500 tons.

At the following places factories are either in process of erection or preparations have been made for building in 1902: Sebewaing, Mich., 600 tons; Carrollton, Mich., 600 tons; Mount Clemens, Mich., 600 tons; Croswell, Mich., 600 tons; Greeley, Colo., 800 tons; Eaton, Colo., 500 tons; Fort Collins, Colo., 500 tons.

In the following table is given a list of the beet-sugar factories in the United States, with their location and capacities:

Beet-sugar factories of the United States.

State, and name of company.	Location.	Daily capacity.
		Tons of beets.
MICHIGAN.		
Michigan Sugar Co	Bay City	500
Bay City Sugar Co	do	600
Detroit Sugar Co	Rochester	500
Wolverine Sugar Co	Benton Harbor	350
Peninsular Sugar Refining Co	Caro	600
West Bay City Sugar Co	West Bay City	750
Alma Sugar Co	Alma	600
Holland Sugar Co	Holland	350
Kalamazoo Sugar Co	Kalamazoo	500
Marine Sugar Co	Marine City	350
Lansing Sugar Co	Lansing	600
Saginaw Sugar Co	Saginaw	600
German-American Cooperative Beet Sugar Co	Salzburg	400
Sebewaing Sugar Co	Sebewaing[a]	600
Valley Sugar Co	Carrollton[a]	600
Macomb Sugar Co	Mount Clemens[a]	600
Croswell Sugar Co	Croswell[a]	600
NEW YORK.		
Binghamton Beet Sugar Co	Binghamton	600
Empire State Sugar Co	Lyons	600
COLORADO.		
American Beet Sugar Co	Rockyford	1,000
Colorado Sugar Manufacturing Co	Grand Junction	350

[a] Factories in process of construction.

Beet-sugar factories of the United States—Continued.

State, and name of company.	Location.	Daily capacity.
COLORADO—continued.		*Tons of beets.*
National Sugar Manufacturing Co	Sugar City	500
Western Construction Co	Loveland	1,000
Greeley Sugar Co	Greeley [a]	800
	Eaton [a]	500
	Fort Collins [a]	500
UTAH.		
Ogden Sugar Co	Ogden	350
Utah Sugar Co	Lehi	350
Utah Sugar Co. (Rasping Station)	Springville	350
Do	Bingham Canyon	350
Do	Provo	350
Logan Sugar Co	Logan	400
NEBRASKA.		
American Beet Sugar Co	Grand Island	350
Do	Norfolk	350
Standard Beet Sugar Co	Leavitt (Ames)	500
CALIFORNIA.		
Alameda Sugar Co	Alvarado	800
Los Alamitos Sugar Co	Watsonville	1,000
California Beet Sugar and Refining Co	Los Alamitos	700
Spreckels Sugar Co	Chino	1,000
Do	Crockett	1,200
American Beet Sugar Co	Salinas	3,000
Do	Oxnard	2,000
Union Sugar Co	Betteravia	500
OTHER STATES.		
Minnesota Sugar Co	St. Louis Park, Minn	350
Continental Sugar Co	Fremont, Ohio	350
Wisconsin Sugar Co	Menomonee Falls, Wis	500
Pecos Valley Beet Sugar Co	Carlsbad, N. Mex	200
Washington State Sugar Co	Waverly, Wash	350
Oregon Sugar Co	Lagrande, Oreg	350

[a] Factories in process of construction.

PROPOSED NEW FACTORIES.

Below is given a list showing location, daily capacity, and estimated cost of construction and equipment of the beet-sugar projects now under contemplation. These projects are in different stages of discussion, organization, and capitalization. Some concerns are fully organized and capitalized; in other cases conditions have been canvassed, and organization seems probable. Nearly all these projects are likely to materialize in the future, provided questions affecting the beet-sugar industry are settled.

This list includes only such projects as came to my attention during my investigations of the past year, and is authentic as far as it goes. There are doubtless others of which I have no definite information. To install these factories would require an investment of $49,000,000. In addition, they would require annually a working capital of $9,080,000. They could purchase from the farmers, annually, beets to the amount of [redacted], besides a great many other crude materials, and would employ a large number of laborers.

$14,700,000

List of proposed factories.

Location.	Nominal daily capacity.	Cost of construction and equipment.
	Tons of beets.	
ARIZONA.		
Phoenix	1,000	$1,000,000
Glendale	500	500,000
CALIFORNIA.		
Hemet	500	500,000
Hueneme	500	500,000
Anderson	1,000	1,000,000
Tehama	500	500,000
Los Angeles	1,000	1,000,000
COLORADO.		
Fowler	500	500,000
Denver	500	500,000
Fort Collins	1,000	1,000,000
Arveda	500	500,000
Prowers County	1,000	1,000,000
Longmont	1,000	1,000,000
Amity	500	500,000
INDIANA.		
Shelby	1,000	1,000,000
IOWA.		
Mason City	500	500,000
Missouri Valley	1,000	1,000,000
Toledo	500	500,000
Storm Lake	500	500,000
Fort Dodge	500	500,000
California Junction	500	500,000
IDAHO.		
American Falls	500	500,000
MICHIGAN.		
Port Huron	500	500,000
Chippewa County	500	500,000
Racine	500	500,000
Grand Rapids	800	800,000
Lapeer	500	500,000
Port Austin	500	500,000
Green Bay	500	500,000
Dundee	750	750,000
Caseville	650	650,000
Monroe	600	600,000
Saginaw	500	500,000
Owosso	500	500,000
Chesaning	500	500,000
Grand Rapids	350	350,000
Croswell	700	700,000
Monroe	800	800,000
Howell	500	500,000
Fowlerville	500	500,000
Cass City	500	500,000
Mount Pleasant	500	500,000
Omer	500	500,000
St. Louis	500	500,000
Mason	500	500,000
Pinconning	500	500,000
Charlevoix	350	350,000
Pontiac	500	500,000
Ann Arbor	400	400,000
St. Johns	500	500,000
MINNESOTA.		
Denmark	500	500,000
Little Falls	400	400,000
Newburg	500	500,000
Winona	500	500,000
Crookston	500	500,000
MONTANA.		
Hamilton	500	500,000
NEW YORK.		
Wellsville	500	500,000
Rochester	1,000	1,000,000

List of proposed factories—Continued.

Location.	Nominal daily capacity.	Cost of construction and equipment.
	Tons of beets.	
NEW JERSEY.		
Mount Morris	500	$500,000
NORTH DAKOTA.		
Oaks	500	500,000
Fargo	500	500,000
OHIO.		
Toledo	500	500,000
Sandusky	500	500,000
Norwalk	350	350,000
OREGON.		
Portland	500	500,000
PENNSYLVANIA.		
Shawmut	500	500,000
SOUTH DAKOTA.		
Aberdeen	500	500,000
Kimball	500	500,000
UTAH.		
Uintah	1,000	1,000,000
Bear River Valley	1,000	1,000,000
Gunnison	500	500,000
WISCONSIN.		
Sheboygan	350	350,000
Racine (4 plants)	500	2,000,000
Oconomowok	500	500,000
Waupaca	500	500,000
Watertown	500	500,000
Stephens Point	500	500,000
Beaver Dam	500	500,000
Burlington	500	500,000
Franksville	500	500,000
Kaukauna	500	500,000
WYOMING.		
Wheatland	500	500,000
Cheyenne	1,000	1,000,000
Total		49,000,000

STATISTICS OF THE INDUSTRY IN THE UNITED STATES.

The statistics of factory development, consumption, production, and importation of sugar, etc., have been drawn from the most reliable sources.

THE CENSUS REPORTS.

From Bulletin No. 59 of the Twelfth Census are taken the following tables, which show the growth of the beet-sugar industry in this country during the last two decades:

Number and nominal daily capacity of establishments in 1900, 1899, and 1898.

States and Territories.	1900.		1899.		1898.	
	Number of establishments.	Nominal daily capacity in tons of beets.	Number of establishments.	Nominal daily capacity in tons of beets.	Number of establishments.	Nominal daily capacity in tons of beets.
The United States	[a] 37	22,310	[b] 31	19,110	15	7,500
California	8	9,900	[b] 8	9,900	5	4,000
Colorado	3	1,850	1	350		
Illinois	1	700	1	700		
Michigan	10	4,450	9	4,100	1	400
Minnesota	1	400	1	400	1	400
Nebraska	3	1,260	3	1,260	2	600
New Mexico	1	200	1	200	1	200
New York	3	1,000	2	400	2	400
Ohio	1	400				
Oregon	1	350	1	350	1	350
Utah	4	[c] 1,450	3	[d] 1,100	2	750
Washington	1	350	1	350		

[a] Includes 2 idle establishments.
[b] Includes 1 idle establishment.
[c] Includes 2 auxiliary factories, at which no sugar is manufactured, but juice is extracted from the beets and pumped to a central factory for treatment.
[d] Includes 1 auxiliary factory.

Statistics of beet-sugar factories in 1879, by States, census of 1890. [a]

States.	Number of establishments.	Capital invested.	Average number of wage earners. [b]	Wages paid.	Cost of materials used.	Value of products.
The United States	4	$365,000	360	$62,271	$186,128	$292,572
California	2	215,000	150	39,131	104,724	162,998
Delaware	1	100,000	50	3,140	6,404	8,564
Maine	1	50,000	150	20,000	75,000	111,000

[a] Data from Tenth Census, Manufactures, pp. 94, 101, and 127.
[b] Men, 16 years old and over.

PRODUCTION OF SUGAR IN THE UNITED STATES.

The table below shows the yearly production of cane and beet sugar in the United States for the last twenty-one years. Unfortunately, all of the cane-sugar production is put under the head of Louisiana, but, as a matter of fact, Texas is producing a limited amount of this sugar, having produced 3,238 tons during 1901.

The following further facts can be noted: Beet-sugar production has practically developed in the last thirteen years. The increase in 1901 over 1900 is 140 per cent. In twenty-one years the production of cane sugar has increased 155.11 per cent. The present amount of beet sugar produced is 59.34 per cent of the cane-sugar product.

Production of beet and cane sugar in the United States (according to Willett & Gray, New York City).

Years.	Beet.	Cane (Louisiana).	Total.
	Tons.	*Tons.*	*Tons.*
1880–81	(a)	122,000	122,000
1881–82	(a)	71,000	71,000
1882–83	(a)	136,000	136,000
1883–84	(a)	128,000	128,000
1884–85	(a)	94,000	94,000
1885–86	(a)	128,000	128,000
1886–87	(a)	81,000	81,000
1887–88	(a)	158,000	158,000
1888–89	2,000	145,000	147,000
1889–90	3,000	128,000	131,000
1890–91	3,000	216,000	219,000
1891–92	5,000	161,000	166,000
1892–93	12,000	202,000	214,000
1893–94	20,000	266,000	286,000
1894–95	20,000	317,000	337,000
1895–96	29,000	238,000	267,000
1896–97	38,000	282,000	325,000
1897–98	40,000	310,000	350,000
1898–99	32,000	246,000	278,000
1899–1900	73,000	132,000	205,000
1900–1901	77,000	275,000	352,000
1901–2 [b]	184,606	311,238	495,951

[a] Less than 1,000 tons.
[b] Figures for 1901 inserted by Charles F. Saylor, special agent.

The following tables show the production of sugar during recent years in the United States and its insular dependencies:

Production of sugar in the United States for the four years 1898–99 to 1901–2.

	1898–99. [a]	1899–1900. [a]	1900–1901. [a]	1901–2. [b]
	Tons. [c]	*Tons.* [c]	*Tons.* [c]	*Tons.*
Beet sugar	32,000	73,000	77,000	184,713
Cane sugar (Louisiana)	246,000	132,000	275,000	311,238
Total sugar	278,000	205,000	352,000	495,951

[a] The statistics given in the first three columns are on the authority of Willett & Gray, New York City.
[b] The figures in the last column were compiled by C. F. Saylor, special agent.
[c] Long tons (2,240 pounds).

Production of cane sugar in United States dependencies for the four years 1898–99 to 1901–2.

	1898–99. [a]	1899–1900. [a]	1900–1901. [a]	1901–2. [b]
	Tons. [c]	*Tons.* [c]	*Tons.* [c]	*Tons.*
Hawaii	253,000	259,000	321,000	350,000
Porto Rico	54,000	35,000	80,000	92,000
Philippines	93,000	63,000	52,000	75,000
Total United States dependencies	400,000	357,000	453,000	517,000

[a] The statistics given in the first three columns are on the authority of Messrs. Willett & Gray, New York City.
[b] The figures in the last column were compiled by C. F. Saylor, special agent
[c] Long tons (2,240 pounds).

IMPORTATION OF SUGAR INTO THE UNITED STATES.

Below are given the total imports of sugar from all countries into the United States for a series of years from 1881 to 1901, inclusive. This covers a period of twenty-one years and shows a gradual progres-

sive growth of trade in this product between this country and the various countries supplying it. In this period the total imports of sugar have increased 147 per cent in amount and 41.4 per cent in value.

Imports (general) of sugar into the United States, 1881–1901.

Years ended June 30—	Pounds.	Tons.	Value.
1881	1,946,865,165	869,136	$86,670,624
1882	1,990,449,609	888,593	90,439,676
1883	2,137,819,123	954,383	91,637,902
1884	2,756,416,896	1,230,543	98,262,687
1885	2,717,884,658	1,213,341	72,519,514
1886	2,689,881,765	1,200,840	80,775,744
1887	3,136,443,240	1,400,197	78,411,224
1888	2,700,284,282	1,205,484	74,245,[illegible]
1889	2,762,202,967	1,233,126	88,543,971
1890	2,934,011,560	1,309,826	96,094,[illegible]
1891	3,483,477,222	1,555,123	105,728,[illegible]
1892	3,556,509,165	1,587,727	104,408,[illegible]
1893	3,766,445,347	1,681,448	116,255,[illegible]
1894	4,345,193,881	1,939,818	126,871,[illegible]
1895	3,574,510,454	1,595,763	76,462,[illegible]
1896	3,896,338,557	1,739,436	89,219,[illegible]
1897	4,918,905,733	2,195,940	99,066,[illegible]
1898	2,689,920,851	1,200,857	60,472,[illegible]
1899	3,980,250,569	1,776,897	94,964,[illegible]
1900	4,018,086,530	1,793,788	100,250,[illegible]
1901*	4,808,661,124	2,146,724	122,505,[illegible]

*Including imports from Hawaii and Porto Rico, as in previous years.

CONSUMPTION OF SUGAR IN THE UNITED STATES.

The following table shows for each year, during the past twenty-one years, the consumption of sugar, the yearly increase of consumption, and the per capita consumption for each year. The consumption has practically doubled in the last eighteen years, and in the entire period it has increased 138.77 per cent. This per cent of increase divided by the number of years in the period gives 6.94 as the average annual per cent of increase.

This rate is sometimes used as a factor in estimating future consumption. But this can not be properly done unless the figures for consumption for 1881 are used as the basis. If the figures for a particular year (1901, for instance) are used as a basis for estimating the consumption for the following year (1902) the results will be incorrect, being considerably too large. A great many have made a misuse of this per cent of annual increase of consumption.

Mr. Frank H. Hitchcock, chief of the Section of Foreign Markets, United States Department of Agriculture, was asked by me to derive the true factor for computing consumption from year to year, and in response to my request, he derived the factor 4.45 per cent for computing our consumption of sugar for 1902 from that of 1901. Mr. Hitchcock's communication, with the formula, follows:

U. S. DEPARTMENT OF AGRICULTURE,
SECTION OF FOREIGN MARKETS,
Washington, D. C., February 17, 1902.

DEAR SIR: In reference to your inquiry of Saturday, the 15th instant, as to an average annual rate to be used in estimating the probable future consumption of sugar in the United States, I would suggest 4.45 per cent.

I have arrived at this rate by taking the consumption figures for the first and last years of the period 1881–1901 and employing the usual algebraic formula for compounding, viz:

$$A = P \times (1+r)^n$$

from which we derive as the formula for obtaining the rate—

$$r = \sqrt[n]{\frac{A}{P}} - 1$$

r = Average annual rate of increase.
n = Number of years.
P = Amount for first year of period.
A = Amount for last year of period.

Taking the period 1881–1901, for the first year of which, according to Willett & Gray, the actual consumption was 993,532 tons, and for the last year of which, according to the same authority, the actual consumption was 2,372,316 tons, and applying the above formula, there being twenty years from the first to the last year of the period, we obtain the following:

$$r = \sqrt[20]{\frac{2,372,316}{993,532}} - 1 = 0.0444786 = 4.44786 \text{ per cent, or about } 4.45 \text{ per cent.}$$

This rate of increase differs materially from that given by Messrs. Willett & Gray, of New York City, for the twenty years subsequent to 1881. Apparently Willett & Gray merely compared the consumption of 1881 with that of 1901, and finding the percentage of increase in the latter year over the former amounted to 138.77 per cent, they divided by 20, the number of years in the period of increase, to ascertain the annual average rate of increase for that period, and obtained a rate of 6.94 per cent. In estimating future consumption, however, an average rate obtained after Willett & Gray's method could hardly be considered accurate.

Very truly, yours,

FRANK H. HITCHCOCK.

Mr. C. F. SAYLOR,
Special Agent, Department of Agriculture.

Consumption of sugar in the United States, 1881–1901.

[According to Willett & Gray.]

Year.	Total amount of sugar consumed.	Increase (+) or decrease (−).[a]	Consumption per capita.
	Tons.[b]	*Per cent.*	*Pounds.*
1881	993,532	.....	.....
1882	1,061,220	+ 6.80	.....
1883	1,170,375	+10.30	.....
1884	1,252,366	+ 7.00	51.00
1885	1,254,116	+ 0.14	49.95
1886	1,355,809	+ 8.11	52.55
1887	1,392,909	+ 2.73	53.11
1888	1,457,264	+ 4.62	54.23
1889	1,439,701	− 1.21	52.64
1890	1,522,731	+ 5.80	54.56
1891	1,872,400	+22.96	67.46
1892	1,853,370	− 1.10	63.76
1893	1,905,862	+ 2.83	63.83
1894	2,012,714	+ 5.08	66.64
1895	1,949,744	− 3.27	64.23
1896	1,940,086	− 0.53	60.9
1897	2,070,978	+ 6.79	63.5
1898	2,002,902	− 3.29	60.3
1899	2,078,068	+ 3.75	61.0
1900	2,219,847	+ 6.82	66.6
1901[c]	2,372,000	+ 6.85	68.4

[a] As compared with the previous year.
[b] Tons of 2,240 pounds.
[c] The figures for 1901 have been inserted by Charles F. Saylor, special agent.

The rapid growth in consumption of sugar may strike one at first as hard to understand, but a closer investigation reveals that it is one of the natural results of the rapid development that characterizes all the industries of this country. Not only is sugar used as an article of diet, but it is required in large quantities in the manufactures, arts, and sciences, this being the principal cause of the growth of consumption. While it is a fact that the daily table use of this article grows as wealth accumulates, this would not by any means account for the large increase in consumption. Throughout the whole country, especially in the mountain and Western States, we have been rapidly developing very productive fruit districts. Irrigation has played an important part in extending the fruit industry. These orchards and patches of small fruits have been coming gradually into production. Many of them are distant from the markets. Their products are of a perishable nature, and can not be distributed to consumers in a fresh state. Canning industries and preserving industries of all kinds have been installed to work up these products. Sugar is required in large amounts in preserving and canning fruits. Like other industries, the prepared-fruit industry has to find a market. It has accomplished this, not only at home, but to some extent in foreign countries. Each year sees a large increase in the supply of fruit that must be treated in this way, and each year has seen a consequently large growth in our home and foreign trade in these products. Naturally the increase in the demand for sugar in this direction has been enormous; yet the fruit industry is only in its infancy.

FACTORY RESULTS FOR 1901.

The following table is made up from data reported to me by the various factories of the United States, covering their actual work during the past year. The figures entering into the tables represent actual returns, with the following exceptions:

First. Two factories did not respond to my request for data. In those instances estimates were made from other information at hand.

Second. Four or five factories failed to fill out a few of the blanks in their replies, and in order to make the table complete throughout, estimates were made from other information at hand and by comparison with the results of other factories.

Third. As it is not desirable to disclose the identity of the factories, each factory is indicated by a number.

The second table is made up of data derived from the first, and gives a very complete and interesting exposition of the results obtained by the sugar factories of this country in their actual work.

Results of factory operations in the United States, campaign of 1901.

Factory number.	Area of beets harvested.	Quantity of beets worked.	Sugar in the beet.	Coefficient of purity.	Quantity of sugar produced.		Amount of fuel used.			Limestone used.	Factory laborers.			Season opened.	Season closed.	Length of campaign.	Crop conditions.
							Coal.	Oil.	Wood.		Number.	Daily wages.	Total wages.				
	Acres.	*Tons.*	*Per ct.*		*Pounds.*	*Tons.*	*Tons.*	*Barrels.*	*Cords.*	*Tons.*						*Days.*	
1	3,200	25,200	13.8	82	5,000,000	2,500	3,707	.....	.....	1,505	178	$1.48	$19,212	Nov. 5	Jan. 17	73	Fair.
2	2,793	21,400	13.6	84.9	4,337,983	2,169	4,226	.....	.....	1,389	155	1.50	15,578	Oct. 16	Dec. 22	67	Do.
3	1,800	12,300	12.7	76.2	2,492,000	1,246	3,300	.....	.....	1,035	160	1.92	20,000	Oct. 14	Dec. 18	65	Poor.
4	7,100	65,000	14.8	83	14,200,000	7,100	13,000	.....	.....	5,200	275	1.88	62,040	Oct. 1	Jan. 28	120	Fair.
5	4,600	40,000	14.6	82.3	8,200,000	4,100	10,000	.....	.....	2,800	175	1.80	38,745	Oct. 1	Feb. 1	123	Average.
6	7,000	61,000	14.2	84	13,750,000	6,875	10,350	.....	.....	3,462	275	2.00	60,500	Oct. 3	Jan. 20	110	Fair.
7	820	9,841.8	12.6	79.5	1,771,500	885.7	1,600	.....	.....	690	128	1.75	18,368	Oct. 30	Jan. 20	82	Average.
8	6,000	58,000	14.3	83.1	11,660,000	5,830	10,000	.....	.....	9,700	270	1.87	59,073	Oct. 5	Jan. 30	117	Good.
9	3,000	28,789	13.6	86.6	5,800,000	2,900	4,100	.....	.....	2,000	120	1.85	20,000	Oct. 10	Jan. 8	90	Fair.
10	4,200	31,600	14.5	84	6,624,000	3,312	6,300	.....	.....	2,200	210	1.99	32,164	Oct. 16	Jan. 1	77	Do.
11	6,000	43,500	14.4	82	8,100,000	4,050	9,000	.....	.....	2,744	275	1.90	46,000	Oct. 19	Jan. 15	88	Do.
12	3,619	26,134.5	13.5	82.5	4,962,000	2,481	7,500	.....	.....	2,575	275	2.00	53,900	Oct. 26	Feb. 1	98	Poor.
13	3,110	28,000	14.5	83	7,000,000	3,500	5,600	.....	.....	2,850	250	2.00	40,500	Oct. 10	Jan. 1	81	Fair.
14	5,200	45,000	14.5	83	9,000,000	4,500	9,500	.....	.....	3,000	250	2.08	50,000	Oct. 28	Feb. 1	96	Average.
15	3,300	22,000	14	82	4,400,000	2,200	4,500	.....	.....	2,250	220	1.75	21,175	Jan. 18	Mar. 13	55	Do.
16	6,000	54,000	14.5	82.5	10,800,000	5,400	10,800	.....	.....	5,500	275	1.88	51,183	Sept. 30	Jan. 7	99	Do.
17	2,470	18,245	14.8	82.3	3,466,550	1,733.3	3,101	.....	.....	1,277	220	2.16	38,016	Nov. 1	Jan. 20	80	Poor.
18	3,200	28,000	14	81	5,400,000	2,700	5,950	.....	.....	3,000	300	2.11	36,000	Sept. 24	Dec. 25	57	Good.
19 [a]	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
20	3,200	32,125.3	14.2	82.2	7,001,000	3,500.5	8,000	.....	.....	4,000	225	1.83	35,844	Oct. 7	Jan. 2	87	Poor.
21	4,717	37,985	12	76.5	7,911,300	3,955.7	7,006	.....	.....	4,878	250	1.97	38,000	Sept. 21	Dec. 7	77	Fair.
22	1,000	4,000	18	85	1,040,000	520	800	.....	.....	425	120	2.00	2,640	Oct. 20	Oct. 31	11	Poor.
23	5,600	64,650	15.7	80	14,224,000	7,112	16,162	.....	.....	3,880	200	2.13	54,528	Oct. 28	Mar. 5	128	Good.
24	9,969	93,559	17	82.2	24,247,600	12,123.8	19,950	.....	.....	8,610	450	2.35	114,086	Oct. 2	Jan. 18	108	Fair.
25	3,100	30,420	17.5	85	7,900,000	3,950	6,000	.....	.....	2,200	180	2.23	30,150	Oct. 6	Dec. 20	75	Do.
26	7,000	78,500	15.2	84	18,350,000	9,175	11,000	.....	.....	4,500	275	2.00	45,100	Sept. 25	Dec. 16	82	Good.
27	3,206	41,461	13	82	8,000,000	4,000	6,100	.....	.....	2,144	132	1.80	28,037	Sept. 14	Jan. 9	118	Fair.
28	2,300	23,305	13.8	82.6	4,360,000	2,180	3,902	.....	.....	1,238	121	2.23	20,225	Nov. 9	Jan. 23	75	Do.
29	1,500	10,500	17	85	2,200,000	1,100	1,375	.....	.....	850	135	1.80	12,150	Oct. 1	Nov. 20	50	Do.
30	2,300	12,719	16	85	3,066,000	1,533	.....	.....	4,000	780	150	1.90	16,000	Sept. 22	Nov. 7	56	Do.
31	6,557	67,251	15.2	81.2	14,698,000	7,349	.....	37,219	.....	7,613	143	2.22	40,626	Aug. 19	Dec. 24	128	Good.
32	3,465	35,897	14.2	80	6,998,000	3,499	.....	22,966	.....	3,042	134	2.21	31,963	Sept. 3	Dec. 19	108	Do.
33	5,710	24,013	14	76.7	4,902,000	2,451	.....	23,074	.....	3,810	338	2.17	30,809	July 25	Sept. 6	42	Poor.
34	5,183	25,112	17.5	80.9	6,166,000	3,083	7,400	.....	.....	1,895	173	1.52	22,569	Aug. 15	Nov. 10	86	Poor.
35	6,000	56,000	17.2	82.5	12,000,000	6,000	.....	36,379	.....	3,032	175	2.11	44,974	July 20	Nov. 20	122	Good.
36	11,399	163,860	16.9	81.8	41,783,800	20,891.9	.....	190,271	.....	20,048	750	2.22	201,717	July 11	Nov. 10	121	Do.
37	19,665	271,321	16.5	82.6	57,400,000	28,700	.....	359,600	.....	37,200	800	2.20	214,720	Sept. 5	Jan. 8	122	Fair.
38 [b]	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Total and av'ge	175,083	1,685,688.6	14.8	82.2	369,211,733	184,605.9	210,229	669,509	4,000	163,322	8,762	2.16	1,666,602	.....	.....	88.2	

[a] Beets shipped to factory No. 20.

[b] Beets shipped to factory No. 37.

Results of factory operations in the United States, campaign of 1901.

Factory number.	Area of beets harvested.	Average yield per acre.	Beets worked.		Coal used.		Fuel oil used.		Limestone used.		Ratio of materials to beets.[a]			Cost of working beets per ton for—				Sugar produced.	
			Tons.	Cost.	Tons.	Cost.	Barrels.	Cost.	Tons.	Cost.	Coal.	Fuel oil.	Lime stone.	Labor.	Coal.	Fuel oil.	Lime-stone.	Per acre.	Per ton.
											P. c.	*P. c.*	*P. c.*					*Lbs.*	*Lbs.*
1	3,200	7.9	25,200	$113,400	3,707	$11,121			1,505	$3,010	14.7	.....	6	$0.762	$0.441	.....	$0.119	1,563	198
2	2,793	7.7	21,400	96,300	4,226	12,678			1,389	2,778	19.7	.....	6.5	.728	.592	.....	.130	1,553	203
3	1,800	6.8	12,300	55,350	3,300	9,900			1,035	2,070	26.8	.....	8.4	1.626	.805	.....	.168	1,384	203
4	7,100	9.2	65,000	292,500	13,000	39,000			5,200	10,400	20	.....	8	.954	.600	.....	.160	2,000	218
5	4,600	8.7	40,000	180,000	10,000	30,000			2,800	5,600	25	.....	7	.969	.750	.....	.140	1,783	200
6	7,000	8.7	61,000	274,500	10,350	31,050			3,462	6,924	17	.....	5.7	.992	.509	.....	.114	1,964	225
7	820	12	9,841.8	44,287	1,600	4,800			690	1,380	16.3	.....	7	1.866	.488	.....	.140	2,160	180
8	6,000	8.8	53,000	238,500	10,000	30,000			9,700	19,400	18.9	.....	18.3	1.115	.566	.....	.366	1,943	225
9	3,000	9.6	28,789	129,550	4,100	12,300			2,000	4,000	14.2	.....	6.9	.695	.427	.....	.139	1,933	200
10	4,000	7.9	31,600	142,200	6,300	18,900			2,200	4,400	19.9	.....	7	1.018	.598	.....	.139	1,656	210
11	6,000	7.3	43,500	195,750	9,000	27,000			2,744	5,488	20.7	.....	6.3	1.057	.621	.....	.126	1,350	180
12	3,619	7.2	26,134.5	117,605	7,500	22,500			2,575	5,150	28.7	.....	9.9	2.062	.861	.....	.197	1,371	190
13	3,110	9	28,000	126,000	5,600	16,800			2,850	5,700	20	.....	10.2	1.446	.600	.....	.204	2,251	250
14	5,200	8.7	45,000	202,500	9,500	28,500			3,000	6,000	21.1	.....	6.7	1.111	.633	.....	.133	1,731	206
15	3,300	6.7	22,000	99,000	4,500	13,500			2,250	4,500	20.5	.....	10.2	.963	.614	.....	.205	1,333	201
16	6,000	9	54,000	243,000	10,800	32,400			5,500	11,000	20	.....	10.2	.948	.600	.....	.204	1,800	200
17	2,470	7.4	18,245	82,102	3,101	9,303			1,277	2,554	17	.....	7	2.084	.510	.....	.140	1,403	190
18	3,200	8.8	28,000	126,000	5,950	17,850			3,000	6,000	21.3	.....	10.7	1.286	.638	.....	.214	1,688	193
20	3,200	10	32,125.3	144,564	8,000	24,000			4,000	8,000	24.9	.....	12.5	1.116	.747	.....	.249	2,188	211
21	4,717	8.1	37,985	170,932	7,006	21,018			4,878	9,756	18.4	.....	12.8	1.003	.553	.....	.257	1,677	208
22	1,000	4	4,000	18,000	800	2,400			425	850	20	.....	10.6	.660	.600	.....	.213	1,040	268
23	5,600	11.5	64,650	290,925	16,162	48,486			3,880	7,760	25	.....	6	.844	.750	.....	.120	2,540	220
24	9,969	9.4	93,559	421,015	19,950	59,850			8,610	17,220	21.3	.....	9.2	1.219	.640	.....	.184	2,432	250
25	3,100	9.8	30,420	136,890	6,000	18,000			2,200	4,400	19.7	.....	7.2	.991	.592	.....	.145	2,548	263
26	7,000	11.2	78,500	353,250	11,000	33,000			4,500	9,000	14	.....	5.7	.575	.420	.....	.115	2,621	239
27	3,206	12.9	41,461	186,575	6,100	18,300			2,144	4,288	14.7	.....	5.2	.676	.441	.....	.103	2,495	197
28	2,300	10.1	23,305	104,873	3,902	11,706			1,238	2,476	16.7	.....	5.3	.868	.502	.....	.106	1,896	180
29	1,500	7	10,500	47,250	1,375	4,125			850	1,700	13.1	.....	8.1	1.157	.393	.....	.162	1,467	214
30	2,300	5.5	12,719	57,236	.....	.....	.....	.....	780	1,560	.....	.....	6.1	1.258	.....	.....	.123	1,333	240
31	6,557	10.3	67,251	302,630	.....	.....	37,219	$13,026	7,613	15,226	.....	55.3	11.3	.604	.....	$0.194	.226	2,242	219
32	3,465	10.4	35,897	161,537	.....	.....	22,966	8,038	3,042	6,084	.....	64	8.5	.890	.....	.224	.169	2,020	195
33	5,710	4.2	24,013	108,059	.....	.....	23,074	8,076	3,810	7,620	.....	96.1	15.9	1.283	.....	.336	.317	858	204
34	5,183	4.8	25,112	113,004	7,400	22,200	.....	.....	1,895	3,790	29.5	.....	7.5	.809	.884	.....	.151	1,190	246
35	6,000	9.3	56,000	252,000	.....	.....	36,379	12,732	3,032	6,064	.....	65	5.4	.803	.....	.227	.108	2,000	214
36	11,399	14.4	163,860	737,370	.....	.....	190,271	66,595	20,048	40,096	.....	116.1	12.2	1.231	.....	.406	.245	3,666	255
37	19,665	13.8	271,321	1,220,945	.....	.....	359,600	125,860	37,200	74,400	.....	132.5	13.7	.791	.....	.464	.274	2,919	212
Total and average	175,083	9.6	1,685,688.6	7,585,599	210,229	630,687	669,509	234,327	163,322	326,644	19.9	108.3	8.8	.989	.598	.379	.194	2,109	219

[a] The percentage figures in these columns simply express the ratio between the number of tons of beets on the one hand and the number of tons, barrels, or cords on the other.

MISCELLANEOUS SUGAR STATISTICS.

Through the courtesy of Mr. Frank H. Hitchcock, chief of the Section of Foreign Markets, Department of Agriculture, the following tables were compiled in order to bring out certain information especially interesting at the present time. The figures given are based partly upon official returns and partly upon statistics published by leading commercial authorities.

These tables contain a fund of information of great value to all persons who are making a study of the sugar question, whether from a practical or an economic standpoint.

Average import price per pound of sugar imported into the United States.[a]

Years ended June 30—	Sugar not above No. 16, Dutch standard.						Sugar above No. 16, Dutch standard.
	Beet.	Cane and other.				Average for all not above No. 16.	
		From Hawaii.	From Porto Rico.	From Cuba.	From other countries.		
	Cents.	*Cents.*	*Cents.*	*Cents.*	*Cents.*	*Cents.*	*Cents.*
1891	2.8	4.2	3.0	3.1	2.7	3.0	3.8
1892	2.8	2.8	2.9	3.1	2.7	2.9	3.8
1893	2.9	2.9	3.2	3.3	2.8	3.1	3.9
1894	3.1	2.9	3.2	3.0	2.7	2.9	3.8
1895	2.0	2.7	1.8	2.2	1.9	2.1	2.8
1896	2.3	3.2	2.1	2.2	2.1	2.3	2.9
1897	1.8	3.1	1.8	2.1	1.9	2.0	2.5
1898	1.9	3.3	1.9	2.2	1.9	2.2	2.4
1899	2.1	3.7	2.3	2.5	2.1	2.4	2.7
1900	2.1	4.0	3.4	2.6	2.2	2.5	3.4
1901	2.2	3.9	3.4	2.4	2.2	2.5	2.7

[a] Based on official returns published by the Bureau of Statistics, Treasury Department. These figures represent the wholesale market prices at the ports of shipment, and do not include the import duty levied in this country, nor the cost of transportation to this country.

Average market price of sugar per pound in New York City.[a]

Calendar years.	89° muscovado.	96° centrifugal.	Granulated.
	Cents.	*Cents.*	*Cents.*
1891	3.4	3.9	4.6
1892	2.8	3.3	4.3
1893	3.2	3.7	4.8
1894	2.6	3.2	4.1
1895	2.9	3.3	4.2
1896	3.2	3.6	4.5
1897	3.1	3.6	4.5
1898	3.7	4.2	5.0
1899	3.9	4.4	4.9
1900	4.0	4.6	5.3
1901	3.5	4.0	5.0

[a] According to statistics published by Willett & Gray, of New York City.

Weekly receipts and market value[a] *of imported sugar at United States ports*[b] *in 1901.*

Weeks ended—	Receipts.	Price per pound of 96° centrifugal.	Value.
1901.	*Tons.*	*Cents.*	*Dollars.*
Jan. 3	7,068	4⅜	692,664
10	43,962	4⅜	4,308,276
17	29,910	4⅜	2,931,180
24	28,112	4½	2,676,262
31	43,287	4½	4,120,922

[a] Based on receipt and price statistics published by Willett & Gray of New York City.
[b] New York, Boston, Philadelphia, and Baltimore.

Weekly receipts and market value of imported sugar, etc.—Continued.

Weeks ended—	Receipts.	Price per pound of 96° centrifugal.	Value.
1901.	*Tons.*	*Cents.*	*Dollars.*
Feb. 7	58,062	4 1/2	5,527,502
14	30,857	4 1/2	2,937,585
21	28,209	4 7/32	2,685,751
28	42,868	4 7/32	4,021,015
Mar. 7	51,609	4 7/32	4,696,419
14	45,149	4	4,045,350
21	36,707	4 3/32	3,314,642
28	39,347	4 3/32	3,552,084
Apr. 4	22,237	4 1/8	2,023,567
11	52,047	4 3/32	4,772,710
18	6,203	4 1/8	561,841
25	49,547	4 7/64	4,647,509
May 2	39,510	4 1/2	3,761,352
9	56,729	4 3/32	5,440,311
16	33,033	4 3/32	3,167,865
23	38,167	4 3/32	3,660,215
31	40,655	4	3,870,356
June 6	38,212	4 1/2	3,637,762
13	64,628	4 1/2	6,152,586
20	44,678	4	4,258,346
27	39,592	4 7/32	3,741,444
July 3	58,884	4 3/32	5,564,538
11	36,368	4 1/8	3,411,318
18	34,769	4 3/32	3,236,994
25	18,647	4 1/8	1,749,089
Aug. 1	22,165	4 3/32	2,065,562
8	14,624	4 1/2	1,351,256
15	23,255	4	2,083,648
22	29,658	4	2,657,357
29	46,168	3 13/16	3,942,747
Sept. 5	17,484	3 7/8	1,468,656
12	39,778	3 7/8	3,341,352
20	37,374	3 7/8	3,139,416
26	12,522	3 7/8	1,051,848
Oct. 3	18,066	3 7/8	1,517,544
10	34,168	3 7/8	2,870,112
17	16,174	3 7/8	1,358,616
24	53,406	3 13/16	4,560,872
31	35,009	3 13/16	2,989,769
Nov. 7	26,122	3 7/8	2,194,248
14	26,463	3 15/16	2,204,368
21	19,275	3 13/16	1,592,115
29	13,421	3 7/8	1,127,364
Dec. 5	11,089	3 7/8	931,476
12	25,430	3 7/8	2,136,120
19	35,432	3 7/8	2,976,288
26	12,409	3 11/16	1,016,297
31	24,460	[a] 3 7/8	1,986,152
Totals and average	1,753,005	[b] 4.07	159,724,614

[a] Quotation of January 2, 1902.

[b] This price is a properly weighted annual average based on the total receipts for the year and their value, as obtained by applying the weekly price quotations to the weekly receipts.

PRODUCTION AND CONSUMPTION OF SUGAR IN THE UNITED STATES GRAPHICALLY PRESENTED.

The present development of the sugar industries of the United States can be illustrated in no better way than by mapping the States and groups of States which produce as much or nearly as much sugar as they consume. Uniting these groups shows the area that our present production of sugar is sufficient to supply. There are three States in which the beet-sugar industry has already developed to the extent of supplying the demands for consumption within their own borders and partially supplying the demand from adjoining States.

The numbers employed in the following tables and maps have been derived as follows:

The population is taken from the reports of the Twelfth Census.

The figures for consumption of sugar are found by multiplying the population by the average consumption of sugar in pounds per capita for the whole country according to the most reliable statistics.

The figures for production of sugar have been made up from actual returns made by manufacturers and estimates made by reliable authorities.

For the purpose of graphic presentation, the States and Territories west of the Missouri and Mississippi rivers are divided into the following groups:

Group I. Washington, Oregon, and California.

Group II. Idaho, Nevada, Utah, and Arizona.

Group III. Montana, Wyoming, Colorado, and New Mexico.

Group IV. Nebraska, Kansas, Oklahoma, Indian Territory, Texas, Arkansas, and Louisiana.

In these tables, after the first one, the totals are carried forward so as to show the comparison of production and consumption of sugar, not only by States and groups, but by combinations of groups.

GROUP I.

Population, and consumption and production of sugar for 1901.

State.	Population in 1900.	Consumption of sugar.	Production of beet sugar.
		Pounds.	*Pounds.*
California	1,485,053	101,577,800	143,947,800
Washington	518,103	35,438,245	2,200,000
Oregon	413,536	28,285,862	3,066,000
Total	2,416,692	165,301,907	149,213,800

The accompanying map (fig. 1) shows the population, consumption of sugar, and the production of beet sugar in Washington, Oregon, and California, the Pacific States, constituting Group I. Ten years ago but little sugar was produced in this area, and that in but one State, California. Now the production nearly equals the consumption, while that of California alone exceeds her consumption by over 42,000,000 pounds. Factories are in operation in each of these States, and others are projected which should largely increase production in the near future. The development of the industry in this section during the past few years may be taken as an indication of the development which may be looked for in other areas during the next decade.

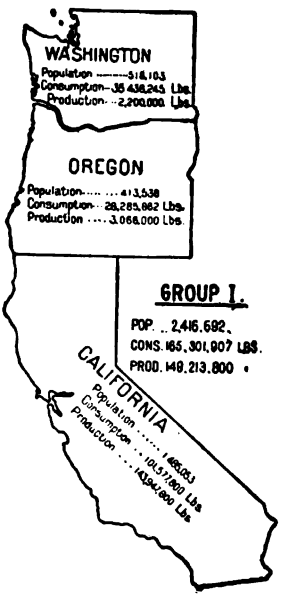

FIG. 1.—Population, and consumption and production of sugar in the Pacific coast States.

GROUP II.

Population, and consumption and production of sugar for 1901.

State or Territory.	Population in 1900.	Consumption of sugar.	Production of beet sugar.
		Pounds.	*Pounds.*
Idaho	161,772	11,060,280	
Nevada	42,335	2,895,714	
Utah	276,749	18,929,651	30,710,000
Arizona	122,981	8,408,480	
Total, Group II	603,787	41,294,125	30,710,000
Group I	2,416,692	165,301,907	149,213,800
Total, Groups I and II	3,020,479	206,596,032	179,923,800

Group II (fig. 2) includes the States of Idaho, Nevada, and Utah, lying almost wholly in what is called the Great Basin, and the Territory of Arizona. Ten years ago there was but one small factory in this area, that at Lehi, Utah. Now there are three sugar factories (one of which has three separate rasping stations), and the product of sugar is nearly three-fourths the amount consumed. A present this production is confined to one State, Utah, in which the production exceeds the consumption by about 12,000,000 pounds. The Utah Sugar Company has increased its capital, and contracted for beets with a view to erecting, in the Bear River Valley, another large factory. A company has been organized and capitalized, and contracts have been made for growing beets with a view to the building of a 1,000-ton factory at Phoenix, Ariz. Projects for the construction of factories in Nevada and Idaho are receiving consideration. On the whole, it is safe to say that this group will soon produce more sugar than the amount consumed.

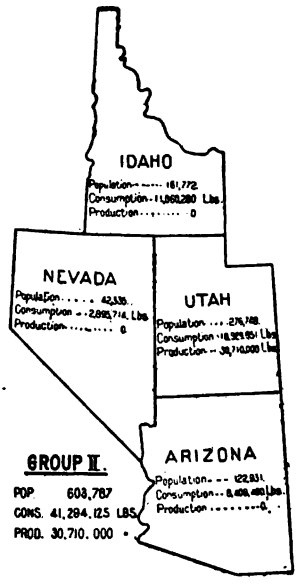

FIG. 2.—Population, and consumption and production of sugar in the Great Basin States and Arizona.

The united totals for Groups I and II show that the production of the combined groups is more than six-sevenths of the amount consumed.

GROUP III.

Population, and consumption and production of sugar for 1901.

State or Territory.	Population in 1900.	Consumption of sugar.	Production of beet sugar.
		Pounds.	*Pounds.*
Montana	243,329	16,643,708	
Wyoming	92,531	6,329,120	
Colorado	539,700	36,915,480	47,411,600
New Mexico	195,870	13,397,508	
Total, Group III	1,071,430	73,285,811	47,411,600
Groups I and II	3,020,479	206,596,032	179,923,800
Total, Groups I–III	4,091,909	279,881,843	227,335,400

In Group III (fig. 3) are included the Rocky Mountain States, Montana, Wyoming, and Colorado, and the Territory of New Mexico. Three years ago every pound of sugar consumed in Colorado was brought in from the outside. Now her production equals her consumption and leaves a surplus sufficient to supply Wyoming, with over 4,000,000 pounds to spare, equal to one-third of New Mexico's consumption. In the group, the production is about two-thirds of the consumption. The production last year was confined to Colorado, in which there are three factories in successful operation, with three more building or preparing to build for the campaign of 1902 with a capacity for producing 37,000,000 pounds of sugar. These alone will make the production of this area considerably in excess of the amount consumed.

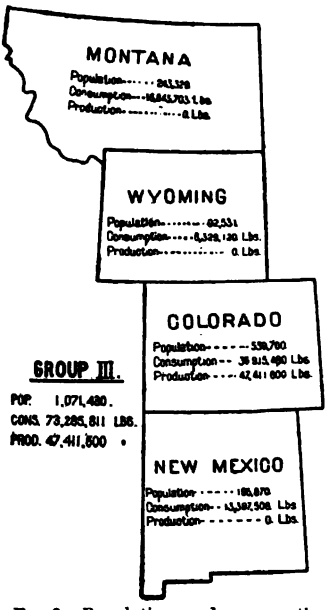

FIG. 3.—Population, and consumption and production of sugar in the Rocky Mountain region.

There is a factory with a daily capacity of 200 tons of beets at Carlsbad, N. Mex., but this was idle during 1901. There are several projects on foot for building factories in Montana and Wyoming. The total production of beet sugar in Groups I, II, and III was thirteen-sixteenths of the amount of sugar consumed.

GROUP IV.

Population, and consumption and production of sugar for 1901.

State or Territory.	Population in 1900.	Consumption of sugar.	Production of sugar.
		Pounds.	*Pounds.*
Nebraska	1,066,300	72,934,920	[a] 14,912,300
Kansas	1,470,495	100,580,858	.....
Oklahoma	398,331	27,245,840	.....
Indian Territory	392,060	26,816,904	.....
Texas	3,048,710	208,521,764	[b] 6,476,400
Louisiana[c]	1,381,625	94,503,150	[b] 616,000,000
Arkansas	1,311,564	89,710,977	.....
Total, Group IV	9,069,085	620,314,413	637,388,700
Groups I–III	4,091,909	279,881,843	[a] 227,335,400
Total, Groups I–IV	13,160,994	900,196,256	864,724,100
Total beet sugar	.....	.....	242,247,700
Total cane sugar	.....	.....	622,476,400

[a] Beet sugar. [b] Cane sugar.

[c] Louisiana's output of cane sugar estimated by A. Bouchereau.

The only beet-sugar producing State in this group (fig. 4) is Nebraska, which has three factories, but produces only about one-fifth of the amount of sugar consumed in the State. Her product added to that of the groups already given raises the aggregate of beet-sugar produced in the four groups to 242,000,000 pounds.

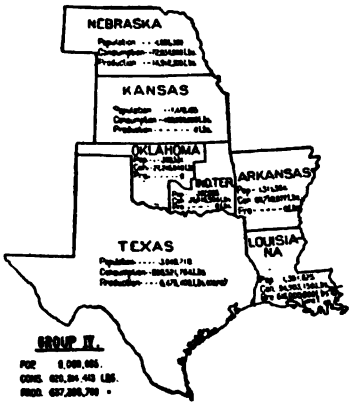

FIG. 4.—Population, and consumption and production of sugar in a group of States lying in the Mississippi Valley and Gulf region.

In the State of Texas a small quantity of cane sugar is produced. Louisiana's product alone is almost equal to the entire sugar consumption of this group.

The accompanying map (fig. 5) shows the area of Groups I–IV in which the total production of sugar exceeds 96 per cent of the amount consumed.

SUGAR PRODUCT OF THE WHOLE COUNTRY.

Beet sugar produced in 1901 outside of Groups I to IV.

	Pounds.
Minnesota	5,400,000
Wisconsin	3,466,550
Michigan	106,267,500
Ohio	2,492,000
New York	9,337,983
Total	126,964,033

It will be observed that the great bulk of the sugar produced east of the Mississippi is made in Michigan, where 13 factories were in successful operation in 1901.

Sugar produced in the United States in 1901.

	Pounds.
Beet sugar, Groups I to IV	242,247,700
Beet sugar, other States	126,964,033
Beet sugar, United States	369,211,733
Cane sugar, United States	622,476,400
Total sugar, United States	991,688,133

If to the beet-sugar product of the four groups mapped, the sugar produced in the other States be added, we have a total of 369,211,733 pounds of beet sugar produced in the United States in 1901. The cane-sugar product of the country (622,476,400 pounds) added to this

gives a grand total of 991,688,133 pounds of sugar produced in the United States last year. This total product is sufficient to cover the consumption of the four groups of States given, together with that of North and South Dakota (50,296,816 pounds), and leave 41,000,000 pounds to apply elsewhere. Therefore, if we add to the area mapped

FIG. 5.—Population and consumption and production of sugar in the territory lying west of the Mississippi and Missouri rivers.

(fig. 5) that of North and South Dakota and about one-fourth of Iowa, we have the territory whose population could have been supplied with the home product of sugar in 1901.

PROSPECT FOR 1902.

New factories will probably be built and prepared to make beet sugar in 1902, whose estimated production is shown, by States, in the following table:

Estimated production of new factories for 1902.

	Pounds.
Arizona	20,000,000
Colorado	36,000,000
Michigan	48,000,000
Wisconsin	10,000,000
Total	114,000,000

The consumption of sugar in Iowa is 156,000,000 pounds. If, then, the product of the factories making sugar in 1901 increases equally with increase in consumption in 1902, the additional product made by these new factories will add to the area of consumption supplied by the home product the equivalent of three-fourths of Iowa's territory.

From these figures it will be seen that the time is rapidly approaching when the United States will produce as much sugar as is consumed in the entire area west of the Mississippi River.

PROBABLE FUTURE OF THE INDUSTRY.

The consumption of sugar in the United States during 1902, calculated from the figures for 1901, will be approximately 2,500,000 tons, and the production (both cane and beet) will reach nearly 500,000 tons. This leaves 2,000,000 tons to be brought in from outside the United States proper. Of this amount Porto Rico should supply 100,000 tons and Hawaii 300,000, a total of 400,000. Deducting this amount from 2,000,000 tons leaves 1,600,000 to be brought from foreign sources paying duty. While the above are only estimates in round numbers, they are believed to be substantially correct.

It is the ambition of those encouraging the sugar industry to establish factories enough at least to supplant this foreign supply. Making due allowance for failure of factories to reach in actual production their full capacity under ideal conditions, it would require 500 factories having a daily capacity of 500 tons of beets to produce this sugar. There will doubtless be an increase in the production of cane sugar in the South which should be taken into account. But for convenience of calculation it is here assumed that the increase will be in beet-sugar production only. To equip and build these factories will require an investment of capital of $250,000,000. This vast sum of money must be expended in this country for building materials and machinery, and in the employment of the labor necessary to construct and equip the factories. The annual result of these factories will be as follows:

Annual requirements and expenditures of 500 beet-sugar factories.

Beets	tons..	18,750,000
Amount paid to farmers for the beets		$84,375,000
Coal	tons..	3,187,500
Amount paid to coal dealers		$9,562,500
Limestone	tons..	1,875,000
Amount paid for limestone		$3,750,000
Coke	tons..	375,000
Amount paid for coke		$3,000,000
Amount paid for labor in the factories		$19,000,000

In addition to the above, large amounts of money will be paid for mill supplies, transportation, etc. As a working capital to operate these factories, about $135,000,000 will be required for the campaign

of four months. This is equivalent to the employment of $45,000,000 for one year. We should remember that the above estimates do not include the capital already invested in the business, the statement of which is as follows:

Present development of the beet-sugar industry.

Capital invested in factories, equipment, and grounds		$30,000,000
Amount of beets purchased annually	tons..	1,875,000
Cash paid for beets purchased annually		$8,437,500
Coal consumed annually	tons..	318,750
Cash paid for coal annually		$956,250
Limestone purchased annually	tons..	187,500
Cash paid for limestone annually		$375,000
Coke purchased annually	tons..	37,500
Cash paid for coke annually		$300,000
Cash paid for labor annually		$1,900,000
Operating capital employed annually		$5,000,000

Also, there is a considerable amount annually expended for various other things, such as crude material, etc. It hardly seems possible that an industry which affects so many people over such a wide scope of country can fail to receive anything but the most friendly, careful, and fostering consideration on the part of those who shape industrial affairs.

The immensity of future demands, it seems, answers pretty effectually those who feel that the industry might be overdone. Attention should be called to the fact that not only are present demands great, but the rate of increase of consumption is considerable.

Five years ago the State of Michigan was making the preliminary inquiries into beet growing and sugar production, and all the sugar consumed was brought into the State. Four years ago 1 factory was constructed, the following year 9, and the next year 3. (See Pl. II.) Four are now in the course of construction for the campaign of 1902. In 1901 the production of the State was very nearly three-fourths the entire amount of sugar consumed. These results were accomplished in four years.

The States of New York, Ohio, Illinois, Wisconsin, Iowa, and Minnesota compare very closely in natural conditions and resources to the State of Michigan. Some of them have natural advantages that Michigan has not. In these States the sugar industry has not been taken up and developed as rapidly as in Michigan, but eventually some if not all of them will be equally important factors in the production of beet sugar. There are several other States that can produce beets of sufficient quantity, quality, and purity. Among them are Pennsylvania, North and South Dakota, and Nebraska, the latter having already made a good start. All the States, beginning with New York in the East and ending with Nebraska in the West, grow sugar beets with moisture supplied by rainfall, and the conditions and methods of agriculture are very much alike throughout.

For the future development of the sugar industry we can look confidently to Colorado, Wyoming, Montana, Idaho, Utah, Arizona, and Nevada. Beet growing under irrigation is peculiarly successful, and may, with its aid, be extended south into Kansas and other States in this latitude. In no other area in the United States is the prospect for future growth of the industry better than in the mountain States. Sugar production in this area means what wheat does to Kansas and Minnesota, what corn does to Iowa and Illinois, what cotton does to Mississippi, Alabama, and other States of the South, and what fruit culture means to California. The arid region will assume agricultural prominence largely through the influence of beet-sugar production as surely as have these through the various products mentioned. Whatever else can be said of the sugar beet, it is a blessing to the arid region.

The States of the Pacific slope produce their agricultural products both by rain and irrigation. These States are destined to assume prominent positions in sugar producing.

The tables given show that sugar production in our country, unlike most other industries, has found its first and greatest success in the West, and from there has progressed eastward. It is preeminently an agricultural interest. In the agricultural group it is destined not only to stand by virtue of its own merits and strength, but to lend liberally of its own resources to the rest of the group, reenforcing their importance. It brings the factory and farm side by side. It brings farmers, laborers, and capitalists into close association and cooperation. It places supply at the door of demand. It meets the logic of modern times in the concentration of advantages and the conservation of forces. It eliminates the foreign grower as a factor in the supply of our daily wants, our business methods, and the emergencies of war.

The development of the beet-sugar industry tends to prevent the concentration of manufacturing interests in some sections of the country, and of agricultural interests in others. It conforms to an ideal system, and simplifies the problems of our social and economic life. It is a great decentralizing power. It can not be compressed into any small area. The factory must go to the place where the beets are grown. It does not pay to ship this raw material any considerable distance. The result is that the beet-sugar factory must be the center of a certain area, and there must be many of these centers distributed generally over the country.

REVIEW OF FACTORY OPERATIONS FOR 1901.

GENERAL OBSERVATIONS.

Taking the United States as a whole the crop conditions, so far as sugar beets are concerned, were quite favorable. Better results were obtained through the whole country during the past year than during

A REPRESENTATIVE MICHIGAN FACTORY, CARO, MICH.

any previous year. These favorable results can be partially attributed to the effect of experience, both in the factory and on the farm. Both the farmer and the manufacturer are learning how to combat or avert unfavorable conditions. The farmer is learning how to cope with pests, how to render a drought least injurious to his crops, how and when to plant and irrigate. The germinating period of the sugar-beet plant's life is the time of greatest danger. Excessive rain or irrigation is detrimental, and a dry condition of the soil, resulting from insufficient irrigation or rainfall is harmful. The baking of the soil, either by rainfall or irrigation, is fraught with serious consequences when the young plants strive to push through the surface. Methods for overcoming this condition are better understood than heretofore. The beet plant thrives on so many different kinds of soil that the farmer must know the methods to apply to the different ones. As the sugar-beet growing area extends, experience and information are acquired.

Year before last beet diseases were prevalent throughout the country. This was unfortunate in its effects on the crop of that year, but it was beneficial in adding to the fund of experience in sugar production. The season before that offered obstacles to the farmer in the form of insect pests, which were quite prevalent. For three seasons previous to 1901 there were unprecedented droughts. On the Pacific coast sugar beets yielded from one-fourth to three-fourths of a crop, southern California suffering the most in this respect. Throughout this time the drought affected the whole country to quite an extent. Disease, insect pests, and drought are the main obstacles to be met in the cultivation of beets. Throughout the sugar-beet growing countries of Europe each of these obstacles has been encountered. It has been found that droughts frequently offer favorable conditions for the prevalence of one or both of the other enemies. By long experience European growers have learned how to deal with these difficulties, and to eliminate them to a great extent, and the season usually closes with favorable results in sugar-beet growing. This country is now going through the same process.

That defeat can be turned into victory finds no better illustration than in the experience with droughts on the Pacific coast. There sugar-beet growers proceed on the principle that the rainfall in the winter and early spring will be sufficient to produce a crop of beets. The soil there has the peculiar quality of conserving sufficient moisture to develop the crop. It is believed that natural subirrigation of the soil takes place in the underground drainage of moisture from the mountains to the sea; that the accumulations of water and snow in the mountains are gradually let down by seepage during the summer, and by capillary attraction brought to the surface in sufficient quantity to supply the growing crop during the season. This is undoubtedly true for the normal year. When the rain and snow in the mountains

fall short in the winter drought follows. The soil is not sufficiently saturated by direct rainfall in the winter, nor is the natural subirrigation sufficient during the growing season. Under such conditions poor crops are obtained. This is the explanation of the three-year drought referred to, and the experience taught the sugar-beet growers a lesson. Necessity is the mother of invention. They discovered that irrigation must be introduced to supplement rainfall. Advantage is now being taken of many natural facilities for irrigating lands, and there is constantly more land coming into use in growing sugar beets by irrigation. In many parts of California it is found that deep wells can be sunk, affording a bountiful supply of artesian water, and many of these are flowing wells. This means of securing water supply is in vogue around the Los Alamitos and Chino factories, in the vicinity of Pasadena and Los Angeles, and in many other sections of southern California. Experience with droughts started these people to seeking water, and the success of some induced others to try the experiment, so that, in the end, these droughts must be regarded as a most favorable circumstance. Most of the projects for sugar-beet factories now contemplated in coast sections have in view sugar-beet growing by irrigation.

In reviewing the operations of the various factories during the past campaign, I have begun with the Pacific coast States and moved eastward.

CALIFORNIA.

The results in California during the year 1901 were good. Most of the factories report favorably in regard to the sugar-beet crop. The sugar beets grown in California are always so high in quality and purity that their yield of sugar goes a long way toward making up for the low tonnage of beets in an unfavorable year. But the past year the tonnage has also been good.

An idea can be formed of California's importance in the sugar industry by noting the fact that she is able to provide sugar enough to supply about seven-eighths of the consumption of all the Pacific coast States, which is about 165,000,000 pounds. In this State there are many projects under consideration for further extending this important industry within its borders. It is quite probable that in the near future she will be doubling her present output.

This State has now eight factories, which will be discussed in regular order under the names of the towns in which the factories are located.

ALVARADO.—The Alameda Sugar Company is operating a factory at this place with a daily capacity of 700 tons of beets. This capacity would enable the factory to work 70,000 tons of beets annually and produce under average conditions 7,000 tons of sugar. It began operations August 19 and closed December 24, working a campaign of one hundred and twenty-eight days. The crop conditions were

favorable throughout its farming district. The factory had what is probably its most successful campaign, having secured beets sufficient and manufactured sugar therefrom almost to its nominal capacity.

BETTERAVIA.—The Union Sugar Company is operating a factory at this place of 500 tons daily capacity. It began its campaign September 3 and closed December 19, being in operation one hundred and seven days. The crop conditions for the year were favorable. Its capacity would enable this factory to work about 50,000 tons of beets, producing therefrom about 5,000 tons of sugar. Though the results of its campaign are looked upon as quite favorable, the factory did not nearly reach the limit of its capacity.

CHINO.—The American Beet-Sugar Company is operating a factory at this place of 1,000 tons daily capacity, which under ideal conditions should work up 100,000 tons of beets, producing therefrom about 10,000 tons of sugar. It began its campaign July 25, closing September 6, being forty-two days in operation. The company operating the Chino factory has another in operation at Oxnard having double its capacity. The Chino concern did not finish working its supply of beets, but, after a short campaign, sent the rest of the beets to Oxnard and they were worked up in that factory with its own supply. The crop conditions throughout the past year were below the average. I understand that through some defect or breakage in the machinery it was considered best to close down the Chino factory and finish the work at the Oxnard.

During the past year the factory concluded to facilitate the delivery of beets to the factory by placing at various points in its agricultural district, along the lines of railroads, beet dumps for loading cars by the farmers from wagons. This saves the farmer's time, making it possible for him to dispose of his crop quickly, and the beets are delivered to the factory in train loads.

CROCKETT.—The California Beet and Hawaiian Sugar and Refining Company is operating a beet-sugar factory here of 1,200 tons daily capacity. This concern combines the two functions of refining raw Hawaiian sugar and manufacturing refined granulated sugar from beets. It is unique in this respect. As a refiner it is able to operate the year round. It occurs to most persons unacquainted with the manufacture of beet sugar that it is expensive to put so much money in a beet-sugar plant and have it idle three-fourths of the year; and the question has frequently been asked: "Why not combine with the manufacture of beet sugar some other industry, by means of which the machinery can be used during the balance of the year?" The Crockett factory is working on this idea, and, if successful, it is to be presumed that other sugar factories will adopt some similar plan.

The crop conditions were quite unfavorable in this locality during the past year, with the result that the factory was not able to make a

showing of over one-third of what it could accomplish under more favorable circumstances. It began operations August 15 and closed November 10. When this factory shall work up to its capacity it will be an important factor in sugar production on the coast, as it will then use about 120,000 tons of beets annually, and produce therefrom about 12,000 tons of refined granulated sugar.

LOS ALAMITOS.—The Los Alamitos Sugar Company is operating a factory here with a capacity of 700 tons, which during an ordinary campaign would work about 70,000 tons of beets. It fell short of this about 14,000 tons during the past year. The crop conditions were much better in this district during the past year than in any other during its history. Through irrigation, by means of artesian wells, more certain and satisfactory crop conditions have been secured. The beets grown averaged in sugar content 17.5 per cent, which is a very high figure. The factory began operations July 20 and closed November 20. Some of the best beets grown for the factory were as high in sugar content as 25 per cent, with a coefficient of purity of 93 per cent.

The factory itself is ideal in design, and is destined to be a model sugar-producing enterprise. A comparison of the results of all the factories during the past year shows that only two other factories succeeded in working beets with a lower expense for labor per ton worked.

OXNARD.—The American Beet Sugar Company is operating a factory (Pl. III) at this place of 2,000 tons daily capacity. It began operations July 11 and closed November 10. It is the second largest factory in the United States. It had a good supply of beets, which averaged 16.9 per cent in sugar and 81.8 in coefficient of purity. It has taken advantage of the facilities for feeding pulp by putting in large feeding pens, and is feeding stock with that by-product. The crop conditions were favorable and the factory had one of its most encouraging years.

SALINAS.—The Spreckels Sugar Company is operating a factory here of 3,000 tons daily capacity. This is the largest beet-sugar producing enterprise in the United States, and one of the largest in the world. It began operation July 11 and closed November 10. Under ideal conditions, it should work about 300,000 tons of beets. The crop conditions were fairly good in the beet-growing districts surrounding this factory, but the supply did not reach this figure. It is not improbable, however, that in the near future under favorable conditions this factory will be able to reach the limit of its capacity. It requires time and effort to work the farming element up to the point of furnishing such a large supply. As the farmers realize the full benefits, direct and indirect, and learn to accomplish the work more cheaply and with less effort, what has hitherto been considered a task will become the natural ordinary enterprise of the valley.

FIG. 1.—BOILER HOUSE.

FIG. 2.—FILTER-PRESS STATION.

Interior views of factory at Oxnard, Cal.

WATSONVILLE.—The Spreckels Sugar Company has a factory here of 1,000 tons capacity. The season was fairly good and an average crop of beets was produced by the farmers in the vicinity. This factory is owned and operated by the same company as is the one at Salinas. In order to give that factory more nearly its capacity of beets, those raised for Watsonville were shipped to Salinas to be worked.

The Spreckels Company utilizes the sugar-beet pulp for feeding purposes. It has, during the past season, fed over 600 cows on this pulp with very satisfactory results. In this connection it may be stated that experiments have been made in some of the factories in expressing all the water out of the pulp, thus making its transportation at a low cost possible, a fact which will greatly aid in making of this by-product a regular article of commerce.

OREGON.

LAGRANDE.—The Oregon Sugar Company is operating a factory here of 350 tons. It began operation September 22 and closed November 7, having a campaign of 56 days. The crop conditions were only fair. This factory began operations originally by growing its beets in a valley near the factory, but, after an experience of two years, found that much better beets could be produced in another locality at some dis tance from the factory; as a result most of the beets are produced 10 to 20 miles distant, and are shipped in carload lots.

This case furnishes a striking illustration of the necessity of a careful soil survey of the neighboring region before undertaking the establishment in any locality, of a beet-sugar factory. At the same time, the fact that some railroads have made a rate for sugar beets of 50 cents per ton for 50 miles or less will be a great help where the beets have to be carried some distance.

The factory has had considerable difficulty in getting the farmers interested in the crop. With a good deal of effort it has been able to secure about one-half enough beets to meet its requirement for an ordinary campaign. The beet crop started last spring under very favorable circumstances, but a late frost came on June 4 and did much damage to most farm crops, and seriously injured the beet crop, cutting it down about one-half. The factory itself planted about 1,000 acres to beets, which were raised under its own supervision. It finally harvested about 600 acres, yielding 4,800 tons. I visited this section in October, and talked with some of the local farmers. They had done exceedingly well with beets, which was especially gratifying, since their other crops were poor. One of them had 80 acres of beets from which he secured about 16¼ tons per acre, and for which he received $4.50 per ton, or $73.12 per acre, netting him over the cost of production about $40 per acre. Farmers who deliver beets to the cars get $4 per ton.

WASHINGTON.

WAVERLY.—The Washington State Sugar Company is operating a factory here of 350 tons daily capacity. Like the factory in Oregon, this one has had to struggle along, contending with obstacles, but each year sees considerable improvement, and the future for the enterprise is very much clearer. The crop conditions were only fair in the State during the past year. The farmers did not produce nearly enough beets for the capacity of the factory.

The factory began operations October 1 and closed November 20. The price paid for beets was $5.25 a ton, and it cost about $31 an acre to raise them. The farmers are beginning to see the advisability of feeding pulp. In fact, all the obstacles are being gradually met. The average sugar content and purity were very high this year, being 17 and 85 respectively.

UTAH.

The sugar industry has found specially favorable conditions in the State of Utah. There are conditions in Utah that do not obtain in any of the other States. The people of Utah were educated from the beginning to produce whatever they might need. This grew out of the peculiar history of the people who settled the country. About fifty years ago a commission was sent from the Territory to Europe to secure a beet-sugar factory. Considering the times, facilities for transportation, and the limited resources of those people, the effort was remarkable. This commission succeeded in securing a beet-sugar factory, and brought it back to this country. At that time they could bring it by rail only to the Missouri River. Strongly built wagons were specially constructed for conveying it the rest of the way over the mountains to Salt Lake City. Oxen were purchased, and a caravan started hauling this beet-sugar machinery. They were finally overcome by the snows and storms of winter in the Rocky Mountains. Most of the oxen died, and the people conducting the train made their way to Salt Lake City. In the spring a new outfit of men and oxen started out to recover the machinery and bring it to Salt Lake City, and this was finally accomplished. It appears that the energies of the people were exhausted by this tremendous effort, and the beet-sugar machinery was never installed or put to a practical test.

Agriculture in Utah progressed with the evolution of irrigation. Thirteen years ago a beet-sugar factory was established at Lehi. It had back of it the industry and energy of this class of people. It was bound to succeed. In the pioneer work of this factory it had many things to overcome. The agriculture of the district had absolutely nothing to guide it in the application of irrigation to sugar-beet culture. Whatever is known to-day on that subject has been mostly

derived from the experience of the factory at Lehi, Utah. At first the tonnage, sugar content, and purity of the beets were low. The obstacles have been gradually overcome, and to-day this factory produces sugar at the lowest cost of any in the United States. It has introduced a feature that is unique in sugar production in our country. When it started, this factory had a daily capacity of 350 tons of beets. It was found that the railroads were inadequate to furnish beets sufficient to keep the factory going if the capacity should be increased, inasmuch as at this time they were busy handling other products. The manager, Mr. Cutler, conceived the idea of establishing in different directions from the factory slicing stations. These slicing stations perform only a part of the work of a regular factory. They slice the beets and run the cossettes through the diffusion batteries, extracting the juice, which is limed and sent to the main factory at Lehi. In order to do this the main factory had to be increased in capacity sufficiently to extract the sugar from this juice.

There are three slicing stations, one each at Springville, Provo, and Bingham Canyon. Each has a capacity for slicing 350 tons of beets daily. Those at Springville and Provo work alternately, using the same set of hands. The central factory at Lehi has itself a capacity for slicing 350 tons of beets. This requires that the main factory at Lehi have a capacity for working the juice from 1,050 to 1,100 tons of beets daily. These slicing stations are from 12 to 20 miles from the main factory, and each station works the beets secured in its immediate vicinity. The factory is no longer dependent on any congested condition of railway traffic, since the juice is delivered through these pipe lines instead of by railroad. There is every indication that this system is a success, and the future may see it adopted in many other localities where the conditions require it. It is a system which can be used in almost any section of the country, if the main factory can be established at a point having desirable railroad facilities, cheap fuel, good water, and other suitable conditions. These pipe lines can be run out to other localities having facilities for growing good sugar beets, and these localities will enjoy all the advantages of a main factory, the farmer being able to deliver his beets with a short haul, and secure his pulp.

Utah not only possesses advantages in her well-established irrigation system, but also has many other natural facilities. While it does not possess enough rainfall to grow a crop of sugar beets, it does secure sufficient rainfall in the spring to germinate the seed and start the plants. After that the crop is produced by irrigation. At many points good pure water for factory use can be secured from streams fed by melting snows in the mountains. These streams also afford water power for running electric-power plants which can be utilized to great advantage in sugar factories.

In the irrigated sections it has been found that the resources of the soil can be very much enhanced by artificial fertilization. As these sections grow older the necessity for this will be more apparent. The following statements are given on the authority of Thomas R. Cutler, president of the Utah Sugar Company, of Lehi: It has been recently discovered that in Salt Lake there are two islands affording an abundance of guano. These islands are the rookeries of different species of birds. The first is called Hat Island, more or less round in outline, and having a diameter of about 1½ miles. This is the home of the pelicans of that region, where they go to breed and rear their young, depositing guano, which affords resources for fertilizing the lands. It is estimated that there are about 75,000 tons of guano on this island. These birds feed upon fish, and the guano is very rich in plant food. The other island is called Gunnison, and is the home of the gulls. Its dimensions are about 3½ by 3¼ miles. It has been found that the animal life in the Great Salt Lake is very limited, but there is a species of small shrimp that is quite numerous, and on these the gulls feed. The action of the waves has thrown upon this island for centuries thousands of tons of these small animals, which leave a deposit rich in fertilizer. It is estimated there are on this island in the neighborhood of 285,000 tons of guano and shrimp fertilizer which is worth $55 a ton.

LEHI.—The Utah Sugar Company is operating a factory here having a slicing capacity of 350 tons, and a capacity for working juice from 1,100 tons of beets daily, which includes the juice from its slicing stations. It began operations September 25 and closed December 16. Conditions for sugar-beet growing throughout its agricultural region were quite good during the past year. At Springville about 1,000 acres of beets were harvested. This district secured an average tonnage of 16, with an average sugar content of 16 per cent and a purity of 84, a very remarkable showing for a district having such a large acreage under cultivation. It takes about sixteen to twenty-four hours for the juice from these different stations to reach the main factory through the pipe lines. The fresh pulp from the factory is sold to the consumers at 40 cents per ton, allowing 2,500 pounds per ton, or 2,000 pounds if the pulp is pressed or allowed to stand any considerable length of time. Dairying has developed to a considerable extent under the influence of this factory.

OGDEN.—The Ogden Sugar Company is operating a factory at this place of 350 tons capacity. This factory has been gradually overcoming the obstacles in its way, and during its last campaign succeeded in making a very favorable showing. The crop conditions in the early part of the season were quite unfavorable, but the results at the close were satisfactory. In this section alfalfa, potatoes, tomatoes, wheat, barley, oats, and rye are grown and rotated with sugar beets. Ogden is quite a center for the production and canning of tomatoes and the

production of potatoes. The tomato season comes about the time of the sugar campaign, and interferes to some extent in securing laborers and the delivery of beets in the early stages of the campaign. During the harvest of last fall I secured from a sugar-beet grower of this section the following table on the cost of production:

Cost per acre of growing, harvesting, and delivering a crop of sugar beets.

Rent	$10.00
Preparing seed bed	1.25
Planting	2.20
Bunching and thinning	2.50
Cultivating	.75
Harvesting and delivering to the factory at a distance of 5 to 6 miles, based on 12 tons per acre, at $1.25 per ton	15.00
Total	32.70

This factory under its contract must sell to the farmers 50 per cent of the pulp at 50 cents per ton. The rest of it is sold to a feed company under contract for 20 cents per ton. The factory pays $4.50 flat per ton of beets, except for beets delivered by cars from a distance, in which case the farmers pay 12½ cents per ton on the freight. Considerable feeding is done at this place. It is also quite a dairying district. All of the pulp is very readily sold at the above price.

The beets during the campaign run about 13 per cent sugar and 80 per cent purity. The factory began operations September 14 and closed January 9. Crop conditions were fair. In growing sugar beets most of the farmers in this district practice subsoiling. They do not use the hoe to any considerable extent except at the time of bunching.

LOGAN.—The Logan Sugar Company is operating a factory at this place having a capacity of 400 tons. It began operations November 9 and completed its first campaign January 23. The crop conditions were fair. The factory had a very good season. The beets showed averages as follows: Sugar content, 13.8 per cent; purity coefficient, 82. The farmers rotate grain and alfalfa with sugar beets. There is also considerable interest in dairying.

COLORADO.

The State of Colorado has developed considerable interest in beet-sugar production. All beets grown in Colorado are produced by irrigation. Three of the factories in operation are demonstrating the adaptability of the industry to the agricultural conditions of the State. There are many other places where it can be introduced. Companies are organized for putting in factories at Greeley, Eaton, Longmont, and Lamar. There are quite a number of other enterprises in various stages of consummation.

GRAND JUNCTION.—The Colorado Sugar Manufacturing Company is

operating a factory here of 350 tons. This was the first factory constructed in Colorado and operated its third campaign last year. The locality is very much interested in fruit production. There has been quite an apathy on the part of the farmers in taking up with beet-sugar production, also an inclination to put their best lands, and those that have been under cultivation, into fruit trees. There has been too much of a tendency to grow sugar beets on new lands, in fact to open up these lands with the cultivation of this crop. As a natural consequence sugar-beet growing has not been a success, nor has the factory. These lands are very hard to reclaim, but respond well after having been under cultivation for some time. Sugar beets have never had a fair test. The probabilities are that the progress of the factory will be slow, but whenever it is given a fair chance by the farmers there is no reason why it should not succeed.

ROCKY FORD.—The American Beet Sugar Company is operating a factory here of 1,000 tons daily capacity. The water for irrigation is secured through ditches from the Arkansas River. This factory and the sugar-beet crop have been a success from the start. It is a locality which produces melons and alfalfa, and to some extent small grain. These crops they are rotating with sugar beets. The beets show a high content of sugar and purity. The factory operated its second campaign last year, beginning October 2 and closing January 18. The crop conditions were fair. The results of its last two seasons indicate that the factory will be successful.

SUGAR CITY.—The National Sugar Manufacturing Company is operating a factory (Pl. IV, fig. 1) here of 500 tons capacity. It began operations October 6 and closed December 20. The crop conditions were fair. This factory represents the typical results of establishing a sugar factory in the arid region. It was built out on the raw plain that had never produced any crop except a little grazing. It has now operated two years, and made a success with the beets grown on these new lands. The company owns about 12,000 acres. It is interested in a water reservoir near Leadville, known as Twin Lakes. These lakes are over 200 miles from the lands which they irrigate. Under the laws of Colorado the water in these lakes is measured by the State irrigation engineer and turned into the Arkansas River, and the company is allowed to take out of the same river, near the factory, the amount of water turned in from the lakes, less 5 per cent deducted for evaporation. The farming district produces beets of high quality and purity, and, as the land is gradually improving by cultivation, they are securing a good tonnage. Along with sugar beets they are introducing other crops incident to the agriculture of that section, and will gradually introduce dairying and stock feeding. Where three years ago existed nothing but a wild plain, to-day can be found this large sugar factory, cultivated lands growing all kinds of crops, and a town of 1,500 inhabitants.

FIG. 1.—FACTORY AT SUGAR CITY, COLO.

FIG. 2.—FACTORY AT MARINE CITY, MICH.

LOVELAND.—The Western Construction Company is operating a plant here of 1,000 tons daily capacity. It opened its campaign October 28, and closed March 5. The crop conditions were good. This factory is located in one of the oldest and best agricultural sections of the State. The principal agricultural interests are sheep and cattle feeding, and raising potatoes, alfalfa, and small grain. The locality has a good farming population. Most of the land growing sugar beets was subsoiled the first year. The average tonnage, sugar content, and purity of the beets were very high. This factory went through its first campaign last year. It made the best success of any factory up to this time for its first year's experience. The estimates for cost of growing sugar beets the first year under irrigation were from $40 to $45 per acre. Considering its feeding interests already established with the facilities for feeding alfalfa and grain, it is very likely that this factory will be able to dispose of its pulp at a fair price from the beginning.

NEBRASKA.

Nebraska was one of the first States to go into the sugar manufacture. It has a loose, sandy loam soil, and under favorable rain conditions succeeds very well in the production of sugar beets. The cost of production of beets is probably lower in this State than in most others now growing them, on account of the ease with which the soil can be worked and kept in good condition.

GRAND ISLAND.—The American Beet Sugar Company is operating a factory at this place of 350 tons daily capacity. Year before last the beet growers around this factory were considerably discouraged by the appearance of diseases peculiar to the beet crop. Considerable loss was sustained thereby. During the past year these diseases were not serious in the locality, and the farmers produced a fairly good crop. The company operating this factory also has one at Norfolk, Nebr. The factory at Grand Island was not operated, and the beets produced there were shipped to Norfolk.

NORFOLK.—The American Beet Sugar Company is operating a factory here of 350 tons. The beets raised in this locality year before last also suffered seriously from beet diseases. While these diseases did not recur the past year to any considerable extent, the crop conditions were quite poor. The beets for the factory, however, came from Grand Island as well as from its own farming district, and they had a very good campaign, beginning October 7 and closing January 2.

These two factories of the American Beet Sugar Company have been in operation about ten years. They have had a great many drawbacks in that time, caused by droughts, beet diseases, and disinclination of the farmers to cooperate with them, but they are gradually overcoming these difficulties, and will probably work in the future under more favorable conditions. The factory at Norfolk is run by working two

sets of hands in shifts of twelve hours, thus using twenty-four hours per day, the laborers receiving from 15 to 19 cents per hour.

LEAVITT.—The Standard Beet Sugar Company is operating a factory here of 500 tons daily capacity. Most of the beets are grown on the farms of the Standard Cattle Company. This is one of the largest feeding concerns in the United States. At present it is feeding about 35,000 head of lambs and 4,000 head of cattle. The feeding company experimented with pulp to discover its desirability in fattening sheep and cattle. As a result it promoted the organization of the beet-sugar company, many of those interested in the cattle company taking stock in the sugar company, the prime object being to secure the pulp for the stock-feeding enterprise. The pulp question was settled with this factory in its inception. The combination of these two enterprises is very favorable to both.

The factory operated its second campaign last year beginning September 21 and closing December 7. The lands upon which the beets are grown are of heavy, rich, bottom loam. Beet growing has met with many difficulties in the way of floods, wet seasons, diseases, and insect pests. The lands themselves are among the best that can possibly be used for this crop. The factory has been unfortunate in two unfavorable years. Under normal conditions it will probably succeed well. The crop conditions for the past year were below the average. It opened its campaign September 21 and closed December 7.

MINNESOTA.

The State of Minnesota has conducted many experiments with sugar beets. Their averages of sugar content, purity, and tonnage have always been quite favorable. The State has accomplished a great deal in dairying and raising small grain, especially wheat. Sugar beets afford a new resource for rotation. The crop is grown on prairie lands, largely sandy loams, fertile and easy to work.

ST. LOUIS PARK.—The Minnesota Sugar Company is operating a factory at this place of 350 tons daily capacity. The crop conditions were fairly good in this section during the past year. The factory began operations September 24 and closed its third campaign December 25. It has been unfortunate in having droughts the first two years. The farmers gained a good illustration of the value of the sugar-beet crop in that it succeeded better than most other crops. This company has had difficulty in getting the farmers interested. It has been compelled to go into Iowa and contract for a considerable part of its beets. The farmers in their own locality during the past year, however, grew most of the beets for the factory. The locality possesses many favorable conditions for the sugar industry. It has good home markets, good railroad facilities, cheap fuel, and good limestone. The company may be credited with having fairly overcome most of the difficulties, and in the future will probably be successful.

MICHIGAN.

The State of Michigan had 13 factories in operation the past year, their total nominal capacity being 6,600 tons of beets daily. Four years ago one factory was installed, and the rest of them have been put in operation since that time. The sugar industry in the State is quite illustrative of its introduction in this country. When the industry was started comparatively little was known in the State about the production of sugar beets, or the manufacture of sugar from them. The companies installing these factories were organized, capitalized, and built while the crops were being grown for their campaigns. Each of them began with little or no information, and both manufacturers and farmers derived what they know to-day from actual experience. In addition to those already in operation, four more factories are being built in the State to enter the campaign of 1902, as follows:

New factories in Michigan.

Sebewaing Sugar Company, at Sebewaing	tons..	600
Valley Sugar Company, at Saginaw	do....	600
Croswell Sugar Company, at Croswell	do....	600
McComb Sugar Company, at Mount Clements	do....	600
Added daily capacity for next season	do....	2,400
Present daily capacity	do....	6,600
Total daily capacity for next season	do....	9,000
Investment in plants by September 1, 1902		$9,000,000
Working capital by September 1, 1902		$1,500,000
Total investment by September 1, 1902		$10,500,000

These factories report crop conditions as follows: Five "fair," five "average," two "good," and two "poor."

Thirty other enterprises are organizing to build factories for the campaign of 1902 or 1903.

At the close of the last campaign the Michigan Sugar Manufacturers' Association compiled a report giving statistics of the Michigan beet-sugar industry for the year ending February 15, 1902, which is as follows:

FACTORY STATISTICS.

Beet-sugar factories of Michigan.

No.	Factories.	Location.	Daily capacity.
			Tons.
1	Michigan Sugar Co	Bay City	500
2	Bay City Sugar Co	Bay City	600
3	West Bay City Sugar Co	West Bay City	500
4	German-American Co	Salzburg	400
5	Saginaw Sugar Co	Saginaw	600
6	Alma Sugar Co	Alma	600
7	Lansing Sugar Co	Lansing	600
8	Peninsular Sugar Refining Co	Caro	600
9	Detroit Sugar Co	Rochester	500
10	Marine City Sugar Co	Marine City	350
11	Holland Sugar Co	Holland	350
12	Wolverine Sugar Co	Benton Harbor	500
13	Kalamazoo Sugar Co	Kalamazoo	500
	Total		6,600

The investment in plants on the basis of $1,000 for each ton of daily capacity is $6,600,000. The working capital on the basis of $100,000 for a 600-ton plant is $1,100,000. This working capital is used in making repairs, purchasing seed, assisting farmers, carrying sugar, and paying labor during the period between campaigns.

Total investment by Michigan sugar companies, $7,700,000.

AGRICULTURAL STATISTICS.

Acres beets harvested	66,400
Contractors or families raising beets	16,848
Acres per contract	3.9
Tons beets raised at 9 tons per acre	597,600
Average per cent sugar in beets	14.1
Value of average ton of beets	$5.20
Amount paid farmers for beets	$3,107,520

LABOR REQUIRED TO RAISE AND MARKET BEETS.

Days for man and team plowing on each contract	2
Days for man and team fitting on each contract	4
Day for man and team seeding on each contract	1
Total days for man and team putting in beets on each contract	7
Total days for man and team putting in beets on entire crop	117,936
Days (April 15 to June 1) used in putting in crop	45
Days' work for 2,621 men and teams putting in entire crop	45
Days' work for one man to block and thin one acre	4
Days' work for one man to block and thin entire crop	265,600
Days (May 15 to July 1) used in blocking and thinning crop	45
Days' work for 5,902 men to block and thin entire crop	45
Days' work for man and horse cultivating one acre	2.5
Days' work for man and horse cultivating entire crop	166,000
Days (June, July, and August) used in cultivating crop	90
Days' work for 1,844 men and horses cultivating entire crop	90
Days' work for man to hoe one acre	3
Days' work for one man to hoe entire crop	199,200
Days (July and August) used in hoeing crop	60
Days' work for 3,320 men to hoe entire crop	60
Days' work for man and team to lift one acre	5
Days' work for one man and team to lift entire crop	332,000
Days (October) used in lifting crop	30
Days' work for 1,106 men and teams to lift entire crop	30
Days' work for one man to top and pit one acre	5
Days' work for one man to top and pit entire crop	332,000
Days (October) used in topping and pitting crop	30
Days' work for 11,066 men to top and pit entire crop	30
Days' work for man and team to haul one acre	2
Days' work for one man and team to haul entire crop	132,800
Days (Oct., Nov., Dec., and Jan.) used to haul crop	120
Days' work for 1,107 men and teams to haul entire crop	120

Summary of men and teams employed in raising beets during summer and fall of 1901.

From April 15 to June 1, 2,621 men and two-horse teams putting in crop.
From May 15 to July 1, 5,902 men blocking and thinning.
From June 1 to September 1, 1,844 men and single horses cultivating.
From July 1 to September 1, 3,320 men hoeing.

From October 1 to November 1, 1,106 men and two-horse teams lifting.

From October 1 to November 1, 11,066 men topping and covering.

From October 1 to February 1, 1,107 men and two-horse teams hauling.

In estimating the cost of raising and marketing the crop the rate of wages is considered as follows:

For man, $1.37½ per day.

For man and single horse, $2 per day.

For man, two horses, and tools, $2.75 per day.

At the above rate the cost of labor for raising the beets averages $33.25 per acre and amounts to a farmers' pay roll of $2,208,382. To this should be added a rental value of land at $5 per acre, making $38.25 as the actual cost of raising an acre of beets. The average yield for Michigan is 9 tons per acre. The average cost to farmers per ton is $3.70. The average returns to the Michigan farmer is 9 tons at $5.20 per ton or $46.80, from which should be deducted the cost of 15 pounds of seed at 15 cents per pound or $2.25, leaving net to the farmer $44.55, or a profit of $6.30 per acre over the cost of labor and land rental. If the farmer ships his beets to the factory the freight must be deducted from his $6.30 profit, leaving the final net profit still less.

The above estimate shows 26,966 men, 1,844 single horses, and 4,834 double teams employed during the season. It makes no allowance for bad weather or any of the accidents attendant upon the business. Every man and every team is expected to work every day. The above figures are the minimum. In actual practice, to determine the number of men and teams employed the total should be increased in each case 25 per cent. This increase does not mean a corresponding increase in cost of producing beets, as the men and teams are not under pay during unfavorable weather. Increased thus, the number of men and teams finding employment in raising beets for Michigan factories during the summer and fall of 1901 is as follows: Men, 33,707; single horses, 2,305; double teams, 6,042.

The actual number of contractors raising beets for Michigan factories during the summer and fall of 1901 is 16,848. This represents the same number of farmers' families, and, on a basis of 5 members to a family, represents 84,240 persons actually interested in the agricultural side of the beet-sugar industry of Michigan.

SUPPLIES FOR AN AVERAGE MICHIGAN FACTORY, RATED DAILY CAPACITY 508 TONS, AND ACTUALLY CUTTING 46,000 TONS IN ONE HUNDRED AND FIVE DAYS.

Coal—9,660 tons, at $2.50 per ton	$24,150
Lime rock—3,220 tons, at $2 per ton	6,440
Coke—354 tons, at $5.25 per ton	1,858
Sulphur—21,000 pounds, at 2¼ cents per pound	472
Filter cloth—8,350 yards, at 15 cents per yard	1,252
Oils—2,000 gallons, at 25 cents per gallon	500
Waste—1,550 pounds, at 5 cents per pound	78
Chemicals	1,885
Osmose paper—7,600 sheets, at 10 cents	760
Sugar bags—19,300, at 9 cents each	1,737
Cooperage stock—24,134 barrels, at 26⅔ per barrel	6,355
Barrel linings—24,134, at 2½ cents per barrel	603
Miscellaneous, including stationery, blank books, printing, postage, telegrams, telephones, sugar reports, Dun's reports, and traveling expenses	2,500
Total	48,590

This amount, estimated on 46,000 tons, the average cut of a 500-ton plant for one hundred and five days, is $1.06 per ton of beets.

CAMPAIGN.

The combined daily capacity of the 13 Michigan factories is 6,600 tons.

To cut this year's supply of beets would require all these factories to run to their utmost capacity, ninety and one-half days, without any allowance for shut downs or accidents. The actual average running time for all Michigan factories during the current year is one hundred and five days of twenty-four hours each, which is the same as three hundred and fifteen days of eight hours each, the customary hours run each day by factories in other lines of business. In addition to the one hundred and five days actually used in cutting beets, each factory is obliged to have a full quota of men for a week before beginning to cut beets, and half its quota for ten days after stopping the cutting of beets. This is the same as lengthening the campaign to one hundred and seventeen days with a full force of men. Steam is kept on half the boilers for a period of six weeks exclusive of the one hundred and five days' campaign.

The average rated daily capacity for each Michigan factory is 508 tons. The actual average daily capacity on the basis of one hundred and five days' campaign is 438 tons, or 86.2 per cent of the rated capacity.

LABOR.

During the campaign of one hundred and five days there are employed in a 500-ton factory the following men, half of whom are on each twelve-hour shift. Owing to the work done just before and after the cutting of beets, the actual campaign for the full force is one hundred and seventeen days:

Salaried persons at $135 per month	12
Skilled workmen at $2.25 per twelve hours	57
Common laborers at $1.80 per twelve hours	137
Actual amount paid for labor and salaries during campaign of one hundred and seventeen days (this plant cuts 46,000 tons beets)	$50,310
Average cost of labor during actual campaign per ton of beets	$1.09

During the eight months intervening between campaigns there are employed 12 salaried persons at $135 per month, 10 skilled workmen at $60 per month, and 8 common laborers at $40 per month.

Salaries and wages paid during the eight months intervening between campaigns	$19,360
Total amount paid for salaries and wages during entire year	$69,670
Average cost of labor during entire year per ton of beets	$1.51
Amount paid for labor by the 13 Michigan sugar factories during entire year	$902,376
Men employed in the 13 Michigan sugar factories	2,678

REMARKS.

From the experience of Michigan factories it is found that for the four months of the campaign the repairs, exclusive of labor, on a 500-ton plant are $750 per month, or $3,000 for the campaign. It is also found that the repairs during the off season of eight months amount on an average to $12,000, exclusive of labor. All these plants are new, the oldest (Michigan Sugar Company) being but four years old. As time advances the repair account will materially increase. At the present time such repairs, exclusive of labor, amount to 32 cents per ton of beets sliced.

Notwithstanding the above-mentioned expense for repairing breakage, there is a depreciation resulting from the fact that sugar machinery is run continually, night and day, for four months, and is then allowed to stand idle for eight months, giving an opportunity for corrosion. Further, the machinery is going out of date, and new

and improved machinery must be purchased to take its place. The changes in methods and machinery are rapid, compelling the companies to make extensive changes from time to time to keep the cost of manufacture within the limits established by competition. It is believed that a conservative estimate of the cost of such changes and depreciation is 7 per cent of the first cost of the plant. On a 500-ton plant this item amounts to $35,000 per year, which, added to the cost of repairs resulting from breakage, makes $50,000, or $1.09 per ton of beets sliced by such Michigan factory during the present season.

INTEREST—TAXES—INSURANCE.

The investment and working capital of a 500-ton plant amount to $600,000. At 5 per cent the interest on the same is $30,000.

The assessed valuation on a 500-ton plant, exclusive of bonded indebtedness, is $300,000. The average rate of State, county, school, and municipal taxation combined is 3 per cent, or $9,000.

The amount of insurance carried on a 500-ton plant is usually $200,000; the rate 85 cents.

The amount of insurance carried on sugar in warehouses at factory and elsewhere varies, but is usually about $75,000 for six months; the rate 1 per cent for six months.

The employers' liability insurance against accident to workmen is estimated at $4 per $1,000 of annual pay roll. This pay roll in a 500-ton house amounts to $69,670, making this insurance cost $280 per year.

Boiler insurance in a 500-ton house is usually carried at $40,000; rate one-third per cent per year; cost of premium, $133.

Total yearly cost of all kinds of insurance carried by a 500-ton sugar plant, $2,913.

Amount paid annually for interest, taxes, and insurance in a 500-ton sugar house, $41,913; which estimated on the tons beets sliced during the present season is 91 cents per ton.

BROKERAGE.

All sugar is sold by brokers at the uniform rate of 10 cents per barrel or 3 cents per sack. This expense of 3 cents per hundredweight of sugar is borne by the manufacturer. On the output of a 500-ton plant this item amounts to $2,898 per year, or 6.3 cents per ton beets sliced.

OUTPUT OF SUGAR.

The average output of sugar per ton of beets at the Michigan factories is 210 pounds, which for the present season amounts to 125,496,000 pounds, or 62,748 tons, or 4,183 carloads of 15 tons each. This amount would make a solid train load of sugar 31.6 miles long.

This amount is 75 per cent of Michigan's yearly consumption of sugar. Its value at 4½ cents per pound is $5,647,320.

COST OF MANUFACTURING SUGAR IN MICHIGAN.

Cost of 1 ton beets	$5.20
Cost of supplies per ton beets	1.06
Cost of labor for entire year per ton beets	1.51
Cost of repairs and depreciation per ton of beets	1.09
Cost of interest, taxes, and insurance per ton of beets	.91
Cost of selling sugar per ton of beets	.063
Total cost per ton of beets	9.833
Total cost per 100 pounds refined sugar	4.682

The above estimate includes 5 per cent interest on the total capital invested and 7 per cent annual depreciation on the value of the plant. Leaving out these two

items the cost of manufacturing each 100 pounds of refined sugar is reduced $0.671, or to $4.011.

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By-Products.

The only by-product at present from which Michigan factories derive any income is the final molasses, which equals in gross amount 3 per cent of the weight of beets. Eight factories are now selling this molasses at $2 per ton f. o. b. at the factories. The amount received is not sufficient to pay the expense of wasting the pulp, which expense has not been included in the above estimate. The Bay City Sugar Company last year built a pulp-drying plant at a large expense in order to make pulp merchantable. The experiment was a complete failure. The Alma Sugar Company is this year trying a similar experiment, and hopes to test its pulp drier before the close of the season. The result is entirely problematical.

Beet Seed.

On account of the fact that the beet-sugar industry in the United States is of such recent development it is necessary to import all the seed from Europe. This seed is purchased by the factories in the month of December, distributed to the farmers in April, and paid for by the farmer from the sale of beets in the late fall. Sugar companies are thus obliged to advance money for the cost of seed, paying interest on the same for from eight to ten months.

Beet Contracts.

Contracts with farmers for the growing of beets for the campaign beginning October, 1902, have already been made by all the factories at the old price of $4.50 per ton for beets testing 12 per cent sugar, and an additional 3¾ cents for each one-tenth of 1 per cent above 12. As the average Michigan beet tests 14.1 per cent, the actual price paid by factories is $5.20 per ton.

Railroads.

All the coal, lime rock, coke, machinery, general supplies, sugar, and 50 per cent of the beets are hauled by railroads. The total amount of incoming and outgoing freight averages at each factory $1 per ton of beets sliced; or for the State at large it amounts to $597,600 for the present year. The valuation of Michigan's output of sugar for the present year at 4½ cents per pound is $5,647,320, all of which goes into circulation and is widely distributed. This is but 75 per cent of the present consumption of sugar in Michigan. If there were no sugar factories in the State this $5,647,320 would all leave the State, and a large per cent of it go to foreign countries. By keeping it at home money is easier, general business better, and traffic upon railroads greatly increased.

Last year the Michigan Central Railroad extended one of its branches 20 miles especially to provide beets for the Peninsular Sugar Company at Caro. Several similar extensions have been planned for next season in order to develop new beet tracts.

Agricultural Implements.

The development of the American beet-sugar industry necessitates an entirely new class of agricultural tools and machinery, among which may be mentioned beet-seed drills, beet cultivators, beet hoes, beet pullers, beet knives, and beet forks. It has also increased the use of wagons, plows, and harrows. As yet few labor-saving tools have been invented. The industry is of too recent origin.

MACHINERY.

All the machinery in Michigan sugar factories is of American make and put up by American workmen. The machinery in the earlier Western factories was of German make.

CULTIVATION OF BEET CROPS.

Beets require better preparation of the soil and more careful attention than does any other crop. Wherever farmers undertake the culture of the beet it results in improved methods of farming and helps establish farming upon a scientific basis.

WISCONSIN.

The State of Wisconsin, through its experiment station, has probably carried on more experimentation with sugar beets than has any other State in the Union. These experiments have covered the entire State, and have been well done, practically and scientifically. They cover a series of years, and demonstrate quite thoroughly the favorable conditions for growing sugar beets in many sections. The State has extensive dairy and creamery interests.

MENOMONEE FALLS.—The Wisconsin Sugar Company is operating a factory here of 500 tons daily capacity. Four years ago a factory was established at this place of 350 tons daily capacity. Unfortunately it was not a success. It was built and equipped more along theoretical than practical lines. The farmers grew a large crop of beets for its first campaign, but it was late in construction, and the beets deteriorated to such an extent that they were unfit for the production of sugar. The factory started up and ran for a few days; then it closed down and went into the hands of a receiver, where it remained until last year, when it was refitted and improved at considerable expense. Its campaign began November 1 and closed January 20. The crop conditions were reported poor, yet the district produced a tonnage equal to the average of the United States. The sugar content averaged 14.8 per cent and the coefficient of purity 82.3.

There are five or six organizations in the State ready to install factories at different points. It appears quite probable that within the next two or three years Wisconsin will be an important sugar-producing State.

OHIO.

This is another State that has carried on extensive experiments covering a series of years. These have indicated favorable conditions in the State for sugar-beet culture. The agriculture in the State of Ohio is quite general, and it is well adapted to the introduction of the sugar-beet crop and the manufacture of sugar. The good quality of cheap fuel, facilities for transportation, and home markets are favorable to cheap production. The State has a great many small farms. Experience has shown that small farmers succeed better and quicker in

the beginning with growing sugar beets than the larger farmers farther west.

FREMONT.—The Continental Sugar Company is operating a factory here of 350 tons daily capacity. It began operations October 14 and closed December 18. The crop conditions were poor. The factory has been unfortunate in having two bad years. Farming has been so well and long established with other crops, that it has been quite difficult to get the farmers to take up with sugar-beet growing. The prospects are improving in this direction, however. It is hoped that the factory has passed over its experimental period, and that it will during the coming year enter on a successful career.

NEW YORK.

The State of New York has spent more money for experimentation in sugar beets than any other State. Experiments have been conducted at both the experiment stations. Under Director Roberts, of Ithaca, these experiments were elaborate and comprehended a thorough test of the soil, the best methods of cultivation, selection of seed, and everything in fact that pertains to the success of the beet crop. The lower half of the State is quite generally well adapted to the crop. New York has large dairying and creamery interests and does a great deal of gardening. Farmers are well posted on the value of feeding by-products to dairy cattle. The State has a good quality of cheap fuel, reasonable transportation facilities, and an extensive market for the product. Organizations have been effected at many places, and it looks quite probable that factories will be built in many other sections of the State.

ROME.—Four years ago a factory was built at this place of 200 tons daily capacity. It was a factory of foreign make and old in design. It struggled along through two campaigns and discovered that it had not the capacity or equipment to produce sugar cheap enough to meet competition in the market. It was unfortunate the first year in the selection of its seed, securing a kind that produced beets low in sugar content and purity. This had much to do in discouraging the farmers and those interested in the factory. After working its second campaign it closed down, was finally sold out, and most of the machinery was moved away to be put into use for other purposes.

BINGHAMTON.—The Binghamton Beet Sugar Company is operating a factory here of 600 tons daily capacity. This was the second factory built in the State. It was also foreign in make and design. It had many things to contend with in the beginning, especially the lack of interest on the part of the farming community. It has operated three campaigns, beginning the last one November 5 and closing January 17. It has gradually ingratiated itself into the sympathy of the farming element, and its success is quite assured. Last year it

installed new machinery and improved its equipment sufficiently to raise its daily capacity to 600 tons. From the start it has been able to dispose of its pulp at from 50 cents to $1 a ton.

LYONS.—The Empire State Sugar Company is operating a factory here of 600 tons daily capacity. This was the third factory built in the State, working its first campaign last year, beginning October 16 and closing December 22. The crop conditions were fair. The average sugar content of the beets delivered to the factory was 13.6 per cent and the coefficient of purity 84.9. For a first year's campaign it was fairly successful.

NEW MEXICO.

New Mexico has carried on many experiments in sugar-beet growing under the direction of the Territorial experiment station, also by local societies at various points. It has been found that there is quite a number of valleys which possess the conditions requisite for growing sugar beets.

CARLSBAD.—Five or six years ago a factory was established at this place having a daily capacity of 200 tons of beets, which was operated by the Pecos Valley Beet Sugar Company. This factory was located at a town called Eddy, the name of which has been recently changed to Carlsbad. The machinery was of foreign make and design. It appeared to do quite well, but for some reason has been closed down during the past two years, and the lands growing sugar beets have been put into alfalfa and other crops.

ILLINOIS.

The State experiment station of Illinois has also carried on extensive experimentation with sugar beets and investigated the conditions for growing this crop. Local organizations and societies have been established at various places in the State, and numerous plats of land have been secured and planted to sugar beets. These plats have been supervised by experts and a careful history kept of everything pertaining to the experiments. It has been thoroughly demonstrated that many parts of the State of Illinois possess the conditions for successfully growing beets of good tonnage, purity, and sugar content. There are many organizations and capitalists planning to erect sugar factories at various points in the State.

PEKIN.—The Illinois Sugar Refining Company constructed a factory at this place having 700 tons daily capacity. This factory was built by parties who have been interested in the manufacture of glucose. It was discovered, after operating one campaign, that it would take some time to get the farmers worked up to the point of producing beets sufficient for the factory's needs. An additional equipment was placed in the factory for the manufacture of glucose during the past year.

The beets that were grown for the campaign were sold to the factory at Benton Harbor, Mich., and the Pekin factory has ceased to manufacture beet sugar and has undertaken the production of glucose. Whether or not this is to be permanent has not been made known.

METHODS OF GROWING BEETS.

It is difficult to lay down general directions and rules for growing sugar beets applicable to all localities and conditions. Often expert sugar-beet growers, at public meetings and through the agricultural press, give minute directions covering all the details of this intricate process. Others, each well versed in the process of growing sugar beets, get into arguments and disputes as to the right method. In such cases each may be correct in a measure. The occasion for such disagreements lies in the fact that each person has in mind the right method for a particular locality or set of conditions. A careful study of the different sections of the United States where sugar beets are grown will lead to the conclusion that there is no single road to success in growing sugar beets. Every locality has settled conditions which will materially modify any set of methods that might apply to some other one. There are some settled rules, of course, but to a great extent the various agricultural districts of this country will have to work out each for itself the right method. The person who argues that the ground must be plowed in the fall, in order to receive the benefit of winter frost, is not offering any argument to the Pacific coast, for instance, where many beets are grown. And he who insists that the ground should be rolled in all instances after planting will hazard the crop if his directions are followed in many parts of Nebraska and other sections where the soil is sandy and there are strong winds. In such case a smooth surface offers an excellent opportunity for the wind to carry along the sharp grains of sand, cutting off the plants and destroying the crop.

There can be no general fixed rules regarding the kinds and application of fertilizers. General principles are all right when accompanied by the reasons underlying, but must always be modified to meet local conditions.

With the development of the industry in all the sections which have the necessary conditions, and the acquirement of ample experience both by the farmers in the production of beets and by the manufacturers in the making of sugar, there will come many improvements and eventually a cheapening of production, a result of great importance to all concerned in the success of the industry, because eventually the beet-sugar industry of the United States will have to meet a sharper competition with foreign sugar producers.

There are some things settled, however, about growing sugar beets. It will generally be conceded that the ground should be plowed deep.

and in most instances subsoiled. Before the seed is planted the ground must be thoroughly pulverized by harrowing and by rolling, even if the surface has to be afterwards roughened. Advantage must be taken of the general and prevalent rain conditions. The ground must be moist enough to germinate the seed, either by rainfall or irrigation. Rainfall is best when it can be obtained. In some localities either is used, according to circumstances. Seeds are planted at depths of from one-half to 2 inches, according to the prevailing conditions in the particular locality. The beets must be planted near enough together to produce a beet of a certain size. This spacing depends again upon the locality and the nature and fertility of the soil. The size and quality of the beet depend materially on the right kind of spacing. The beets must be thoroughly cultivated, hoed, and hand weeded, because cultivation tends to conserve the moisture of the soil, and clean fields permit favorable action of sun and air. The sooner the beet is harvested after it is ripe the better, because further rainfall may start a new growth, producing new lateral roots and new leaves, thus greatly reducing the sugar content and purity of the beets.

PREPARING THE SEED BED.

The preparation of the soil for receiving the seed is one of the intricate and expensive parts of the work. The first prerequisite is the selection of the land itself. Sugar beets are a vigorous crop and require a good soil. The old idea that sugar beets can be grown on soil that has been worn-out has been pretty thoroughly exploded, and the sooner it is wholly abandoned the better it will be for the sugar-beet growers as well as for the manufacturers. One of the first errors that the farmers of Michigan fell into was to take their worn-out grain lands and attempt to grow sugar beets on them. The results were quite disastrous but conclusive, and the Michigan farmers are now setting apart their best lands for this purpose. Every old agricultural district in which the industry has been established had to go through this experience. It should be insisted upon that a good, fertile soil is required. Sugar beets will grow in sandy soils, sandy loams, or clay loams if not underlaid with hardpan, but they must be fertile.

Having selected the land, deep plowing is usually required, and in many instances subsoiling is necessary. The main body of the beet should rest in the part of the soil that has been stirred. This prevents the beet from tending to grow up out of the ground and gives a better opportunity for its fine lateral roots to perform their functions.

After the ground has been plowed it should be thoroughly pulverized by disking, harrowing, rolling, and planking. It is not necessary to use all of these methods at once, but enough of them must be used to accomplish the end in view, and that is to thoroughly pulverize the ground. The surface should be left perfectly soft and as smooth as

possible. Special implements are being constantly devised to accomplish this work. The sugar-beet grower can select the implement or implements that perform this service best according to his own needs and conditions.

PLANTING.

The soil being ready, the beets are planted (Plate V, fig. 1) at different depths varying from one-half inch to one and one-half inches, according to the peculiar needs of the soil and the peculiar conditions existing in the soil at the time of planting. This is usually governed by the amount of moisture it contains, the time of year the planting is done, and the tendency of the soil to dry out. Four rows are usually planted at one time. They are usually from 14 to 24 inches apart, depending upon the strength of the soil, whether irrigation is used or not, and, if used, how it is applied. About 20 pounds of seed are used per acre. The seeds are planted from one-fourth to one-half an inch apart in the rows.

The usual price for seed is 15 cents per pound, and the cost per acre at this rate is $3. It will be noted, when we come to the subject of bunching and thinning, that only a small percentage of the seed planted is utilized in the end. In view of the great importance of securing a "stand," this apparent waste of seed seems necessary. Attempts are being made to reduce this item of expense. Some parties have invented a planter that will place the seeds in bunches in the row, the right distance apart, subject to regulation by the planter, instead of sowing them along the row as at present. Another experimenter has adopted the plan of first germinating a seed in a little package filled with soil rich in plant food. After the roots appear through the package, it is deposited by a specially devised planter at the proper place in the row. It is claimed for this process that the moisture in the package will carry the plant along until it has time to take root in the ground. It is also claimed that the well-balanced fertilizer in the package will make a strong, healthful plant in the beginning; also that, while it is a little more expensive in the start, it accomplishes four important purposes: (1) It gives early vigor to the plant; (2) it eliminates the excessive expense for seed; (3) it does away with bunching; (4) it does away with thinning. There can be no doubt that these are four very strong recommendations. If this new method proves a success, it will reduce the cost of growing beets at least one-fifth.

GERMINATION.

If the soil is in proper condition, the temperature favorable, and moisture sufficient, within a week after planting the beets will appear. By irrigation the moisture can be controlled to some extent, but, in the main, weather conditions must be depended on. Hot, dry winds

FIG. 1.—PLANTING SUGAR-BEET SEED, OXNARD, CAL.

FIG. 2.—HOEING SUGAR BEETS, OXNARD, CAL.

FIG. 1.—THINNING BEETS, OXNARD, CAL.

FIG. 2.—CULTIVATING BEETS, OXNARD, CAL.

soon reduce the moisture near the surface where the beet seeds lie. Cold weather retards germination. This germinating period of the sugar-beet plant is the most critical point in its existance, and one on which the farmer must be well posted. If a rain follows planting and bakes the ground, he must know how to overcome the difficulty. He must be thoroughly versed in the use of the harrow in connection with the sugar-beet crop. The old adage, "a stitch in time saves nine", is nowhere more applicable than here. The grower must begin the battle against the plant's enemies—weeds and grasses—immediately with the germination of the beet seed.

BUNCHING AND THINNING.

When the plant has three or four leaves, the bunching must be done. The grower passes down the row, and, with a stroke of the hoe, cuts out a part of the plants, leaving bunches from 6 to 10 inches apart.

After bunching, or when it is fairly under way, the laborers begin the thinning. This is accomplished by crawling along the row, and with the hands extracting from each bunch the excess of plants, leaving a single one. (See Pl. VI, fig. 1.) The thinning time is also a critical period. Should it rain, or the farmer be lacking in help, serious consequences may occur. The beet plants are growing near each other, and in many instances they are twining around each other. They have begun sending out lateral roots. If thinning is not done at the right time and with care, the plants left standing are sure to suffer damage.

CULTIVATING.

The first cultivation is performed in the bunching and thinning, when the operator presses the dirt firmly around the beet plant, and extracts whatever grass or weeds may be present. The second cultivation is done with the cultivator. (Pl. VI. fig. 2 and Pl. VIII). Four rows are usually cultivated at once. The seeder usually plants four rows at once, and the cultivator is run over the same four rows. The driver has only to watch a single row, since any crook in that row will also be found in the other three. The first cultivation is done with sharp, flat knives which run parallel with the surface, cutting off the roots of grass and weeds just below the surface. The cultivator is followed by a laborer with a hoe, who mellows the ground around the beets and draws the dirt up to them.

The next cultivation is usually done with slender, long plow blades, known as "bull tongues," that stir the ground down several inches. This is after the plants have reached some size. Cultivation is continued as the necessities of the case require. Cultivation has two ends in view: (1) To keep the grass and weeds thoroughly removed; (2) to form a dust mulch around the plants to conserve the moisture

in the soil. The cultivator is usually drawn by a single horse or mule and handled by one person.

Cultivating ceases when the plants are large enough to thoroughly shade the ground, and when to continue the work among them with a plow and horse would be detrimental. After that the workmen go over the field and pull out the grass and weeds by hand. (Pl. VII).

Cultivation is one of the most important things in growing sugar beets. Upon thoroughness in keeping down the weeds and grass depends the access of air and light. Light and heat are the active agents in the elaboration of sugar in the beet. The moisture necessary to the growth of the beet also depends a great deal upon cultivation. The influence of cultivation is recognized by the laborers of foreign descent in our sugar-beet fields, who are continually saying: "We have to hoe the sugar into the beets." (See Pl. V, fig. 2).

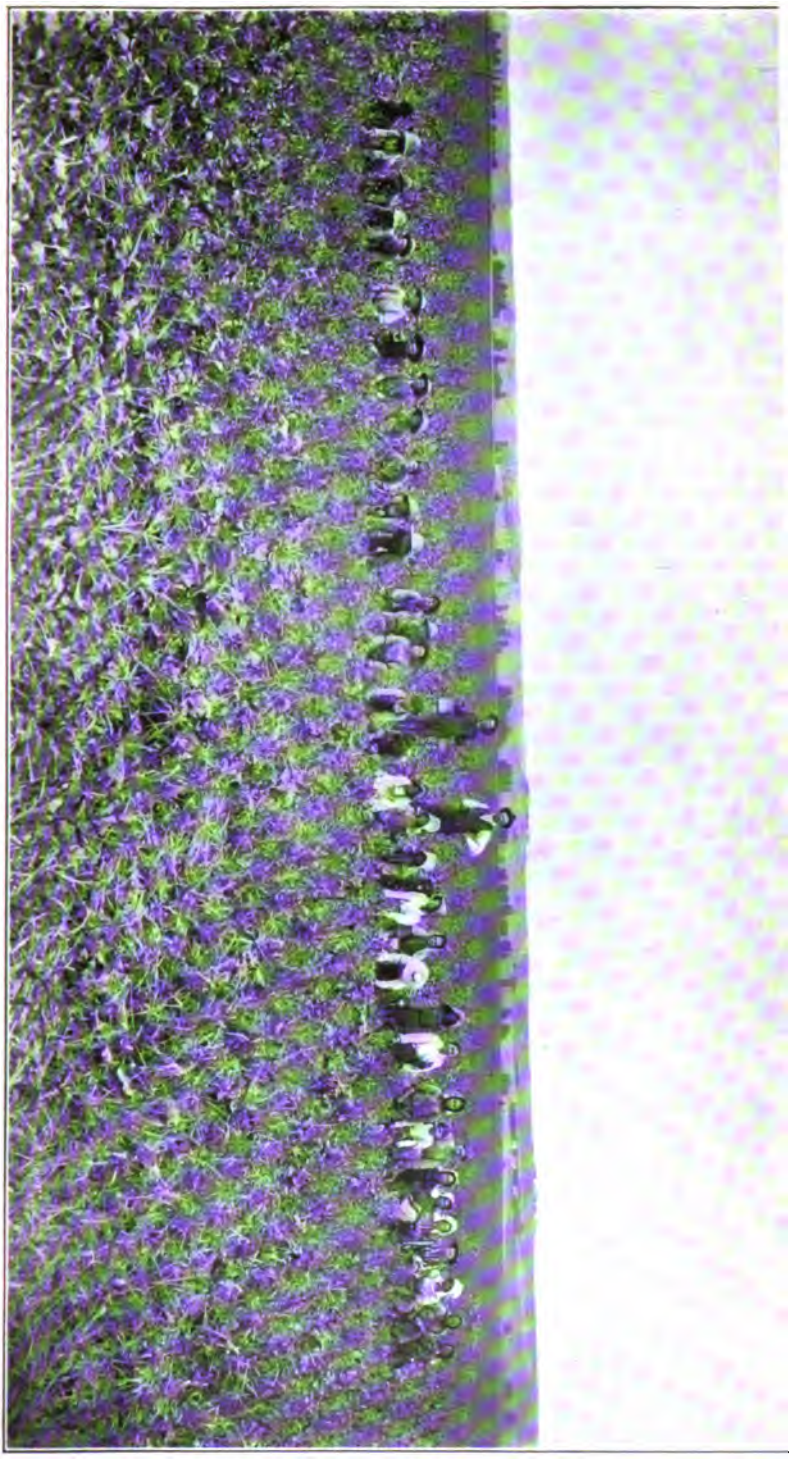
HARVESTING.

When one is accustomed to seeing sugar-beet fields, it is easy to determine when they are ripe. However, this point is usually determined by ascertaining the sugar content and purity of the beets. When a field of beets is ripe, the leaves tend to droop, and the whole field takes on a yellow appearance, which can not be mistaken by one accustomed to deciding the period of ripeness.

Harvesting is done with plows, of which there are several kinds. One has a sharp shear that cuts off the tap roots, and a long, slim moldboard which raises the beets several inches along with the dirt. Another harvesting implement has two prongs with diverging points. These prongs pass along through the soil at some distance below the surface, one prong on either side of a row of beets. The action of the implement is to break off the tap root, lift the beet up a few inches, and allow it to drop back as the plow passes on. Both of these instruments are called "diggers." The digger is followed by laborers who lift the beets and cleave off the tops with sharp knives. This is called topping. The beets are thrown into piles at regular distances, and the tops, with adhering crowns, are allowed to lie in the fields. (See Pl. IX.) The best practice is to plow them under as fertilizer, but in many cases they are fed to stock, or the stock is turned in on them. Sometimes these tops are hauled to market and sold by the load as hay or other forage.

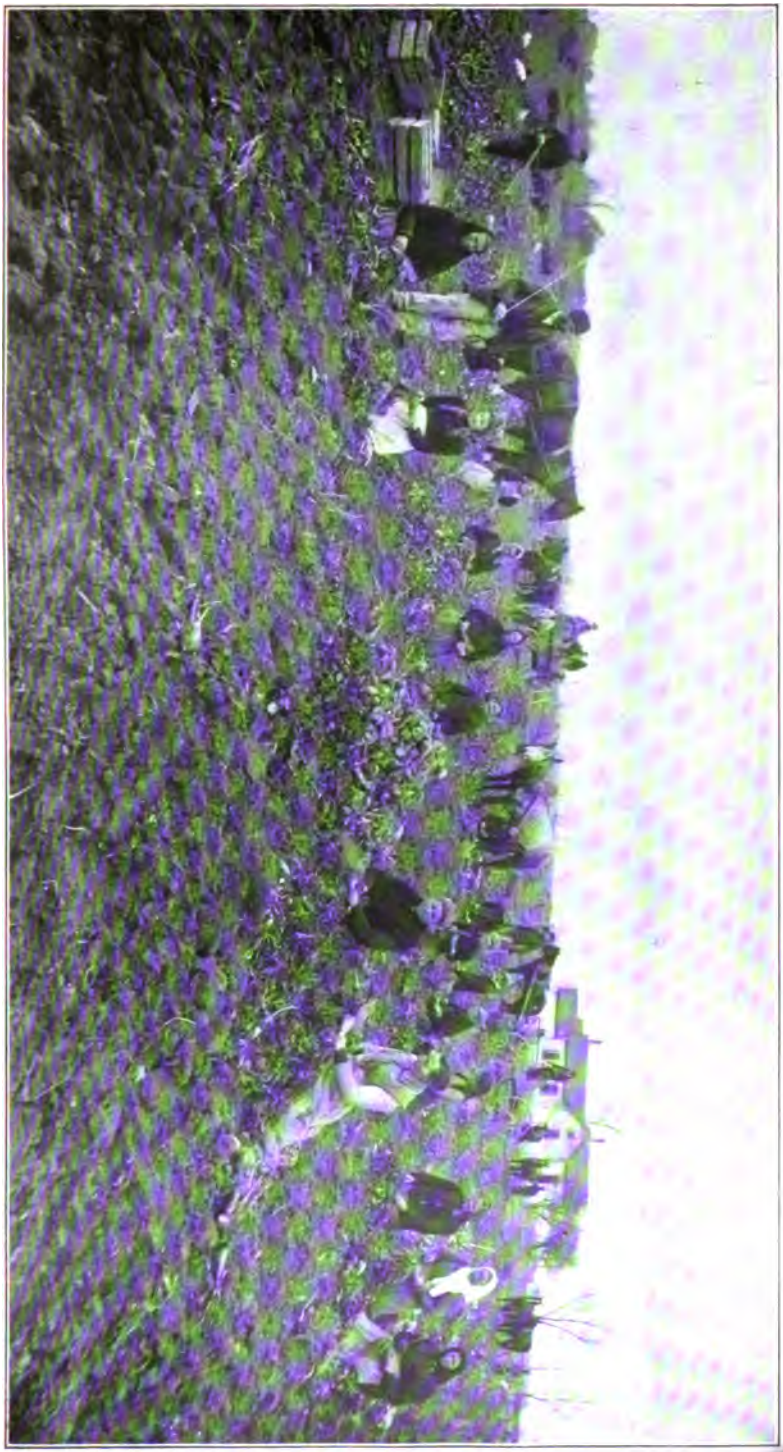
DELIVERING BEETS.

Wagons are driven into the fields, and the beets are either thrown into the open boxes or are put in sacks. Sometimes a net is placed in the wagon, and when the wagon arrives at the factory the whole load of beets is lifted out by machinery. There is as yet no uniform method of unloading beets. The most common practice is to simply shovel



WEEDING BEETS, AMES, NEBR.

CULTIVATING SUGAR BEETS, AMES, NEBR.



HARVESTING SUGAR BEETS, SAGINAW, MICH.

the beets out of the wagon with beet forks or shovels. (Pl. X.) Sometimes special dumps are arranged at the factory whereby whole wagon loads of beets are precipitated at once into the bins. Such dumps are expensive to the factories, and not very many have them put in. One of the best arranged devices for dumping that I have examined is that in use at Fremont, Ohio. Long beet bins are built near to and parallel with each other. Wagons drive in over bin No. 1, and the beets are dumped out of the wagons into the bin. The driveway is constructed over the bins composed of a series of platforms upon which the wagons are driven. Each platform will hold a wagon, and has machinery for dumping the beets. When one bin is full, all these platforms, by means of travelers and a windlass, are moved over to the second bin, which is filled in like manner. This process is repeated until all the bins are filled. One set of platforms and dumps do the work for all the bins.

The farmer usually aims to haul from 2 to 3 tons of beets at a load. This amount depends upon the kind and condition of the road leading to the factory. In many cases special wagon boxes are used for hauling beets. It is found impracticable to haul beets by wagon farther than 7 to 10 miles. If grown farther than this from the factory, they are usually hauled to the cars and delivered to the factory by the carload.

I noticed last year that in several places a new idea in the delivery of beets had been introduced. Special dumps were made at points in the country over side tracks along the railroad. (Pl. XI, fig. 2.) These dumps are fitted with scales for weighing, and arrangements are made for taking samples. Farmers haul their beets to the nearest dump. A long approach is built and up this the farmer drives his wagon, which is then fastened to the platform, and the whole is tilted backwards, precipitating the beets into the car. The whole operation requires about three minutes' time, so that a large number of beet haulers can be accommodated in a short time.

SAMPLES AND TARE.

Whenever a wagonload of beets is delivered to the factory, a basketful, promiscuously selected, is taken out as a sample. This sample is tagged and on the tag is noted the weight of the load of beets. It is then sent to the chemical department of the factory, where it is analyzed for sugar content and purity, thoroughly washed to remove all the adhering dirt or tare, and reweighed. The per cent of tare is thus determined for the particular load from which the sample was taken. The factory may do this with every load or determine the tare by testing only part of the loads.

The question of tare is the cause of constant friction between the farmers and the factory managers. Some kinds of soil adhere more

than others; therefore, some farmers have more tare than others. The same soil sometimes adheres more than at other times, and the farmer gets different rates of tare, so that the tare is constantly a matter of dispute.

SUGAR CONTENT AND PURITY.

The samples used in determining the tare are also used by the chemist in determining the quality of the beets. This information is to complete the records of the factory, in order to compute the extraction of available sugar. Often factories buy beets on a sliding scale, paying so much per ton for beets of certain quality and more for beets higher in sugar content and purity, so that the work of the chemist is important.

SILOING.

While beets should be harvested as soon as they are ripe to avoid the deteriorating effects of frost or rain, yet not all beets can be delivered to the factory at the same time. The beet sheds have not sufficient capacity. Many companies require that a certain portion of the beets shall be siloed in the fields where they are grown. This is accomplished by placing them in single piles containing a good load, or in long ricks. Plows are run up and down alongside of these ricks or piles, and the soft dirt is thrown over the beets to the depth of several inches. Then, hay, straw, and beet leaves are thrown on top of that. Holes are left for ventilation. Beets can be kept for some time in this manner.

FROZEN BEETS.

Throughout New York, Ohio, Michigan, and Minnesota, during the past year, heavy freezing weather occurred before the campaign was half over. Many of the beets grown for factories in these States were frozen solid. I wrote to the factories to get the results of their experience with frozen beets, and found that in no instance did this freezing produce any particularly bad effect. The temperature fell to 20 below zero before the 20th of December, and was as low as that several times before the campaign closed.

NEWS ITEMS AND PRESS COMMENTS.

Under this heading are compiled facts of interest regarding the beet-sugar industry taken from my own notes, and clippings from local papers, especially papers representing the beet-sugar interests. This information is arranged according to States and towns or localities.

CALIFORNIA.

OXNARD.—The following is taken from a recent issue of the Sugar Beet Gazette:

The Patterson Ranch Company's balance sheet shows some very interesting and instructive figures on its last year's business. It is a carefully conducted property,

FIG. 1.—PILE OF BEETS BY RAILROAD; FACTORY AT LOVELAND, COLO.

FIG. 2.—UNLOADING BEETS INTO BEET SHEDS, SUGAR CITY, COLO.

FIG. 1.—WEIGHING BEETS, SAN RAMON VALLEY, CALIFORNIA.

FIG. 2.—BEET DUMP, DANVILLE, CAL.

and an account is kept of acreage, expenses, etc., on every crop raised. While last year was not the most favorable, and the cost of irrigation had to be added to the ordinary expenses of farming, the best crop raised on the ranch was very satisfactory. The company's balance sheet shows gross receipts from beets were $86,120.90, and the average net profit per ton of beets was $2.35, including pasture of beet tops. We give some of the figures:

Acres harvested		1,458
Beets delivered	tons	18,438
Gross receipts		$86,120.90
Sugar content	per cent	17.6
Purity	coefficient	79.6
Tare	per cent	2.78
Price received per ton		$4.67
Average cost of raising per ton		2.37
Average profit per ton		2.29
Average profit per ton, including beet-top pasturing		2.35
Average cost per acre to farm		29.97
Net profit per acre		29.78
Total net profit		43,329.39

This demonstrates, under the least favorable conditions as to season, that beet raising on a large scale is one of the most profitable branches of farming possible in this valley. There are many other instances that would make an equally favorable showing, but there are few ranches as well managed as the Patterson, or where a detailed account is kept of every expense connected with every crop. That fact gives added value to the results in this case.

Intelligent farming and certainty of prices make beets, even in years called bad years, one of the safest and most profitable crops the farmer can raise.

The ranch company was so well pleased with last year's results that it has contracted with the American Beet Sugar Company to plant 1,500 acres in beets this season.

COLORADO.

The following is clipped from the Rocky Mountain News, of Denver, Colo.:

The great value of sugar-beet factories to Colorado can not be estimated by the paltry dollars which the invested capital in the buildings and machinery add to the taxable assets of the State. Compared to other interests directly arising from the location of a sugar plant in any community, these assets are not the most important features. As a safe criterion, we can refer to Otero County, which has welcomed two factories in the past year, at a probable cost of $2,000,000, which has been listed upon the country tax list. But let us look further. These two refineries have brought to the county at least four thousand new people, who have been enrolled as bona fide residents. The farming and agricultural lands have been enhanced in value at least $3,000,000. The business and commercial interests of the county have been quickened by the increased capital which has been placed in circulation. The slipshod custom of careless agricultural methods has been abandoned, and the theory of intense farming has been almost universally resorted to.

The value of an acre of land depends on the amount of cash it will pay its owner each year, and its value can not legitimately rise above this basis. Here is where the great profit in general comes in from the establishment of the factory and the growing of sugar beets. Land which has heretofore produced, when cultivated in ordinary farm crops of alfalfa and grain, from $7 to $10 per acre net to the owner is capable of producing, when properly planted to sugar beets, from $50 to $70 per acre,

besides giving permanent employment to at least four times the number of laborers. Hence, we can see in the starting of every factory the solution of two great problems—the increase of land values and the maintenance of a fourfold greater population.

LOVELAND.—A. V. Officer, manager of the Loveland beet-sugar factory, has interested clergymen and charitable persons in the cities, who are sending him boys to work in the beet fields. The ministers find it a good way to make boys self-sustaining and bring them up to habits of industry, while the beet growers find the boys are excellent workers in the fields.

When the Great Western Construction Company began operations, 30,000 tons of beets lay in the sheds ready to be sliced.

PUEBLO.—The Nuckalls Packing Company, of Pueblo, will erect yards and pens for several hundred head of cattle at Sugar City, to be fattened on the beet pulp from the National Sugar Company's plant.

ROCKY FORD.—Experiments have been conducted at Rocky Ford to determine the value of beet pulp as food for cattle and sheep, and the results have proven highly satisfactory. It has been demonstrated that pulp is a superior food for stock, taking the place of corn at one-third less expense. Many inquiries have been made as to the consistency of the pulp. Many have an idea that it will be mushy. That is the case unless the pulp is pressed dry. I understand the Loveland factory will install machinery for pressing the pulp comparatively dry, which will greatly add to its usefulness for feeding during freezing weather.

Beet pulp from the sugar factory at Rocky Ford has proven so valuable as a food for cattle that the dairy interests are experiencing a boom in that town. A number of herds of milch cattle are being brought to the place, and the production of milk will be greatly increased.

SUGAR CITY.—The following is clipped from a local paper published in the vicinity:

The large amount of land acquired by the National Sugar Company at Sugar City for growing sugar beets will necessitate an addition to the population of that place of 500 laborers in seeding time. In less than one year Sugar City has grown from nothing to a city of 2,000 inhabitants. Laborers from Denver and other places are arranging to go to Sugar City.

ILLINOIS.

The Illinois State board of agriculture offered premiums in 1901 to beet growers as follows:

For largest yield of beets grown on 1 acre of ground: First premium, $50; second premium, $25; third premium, $15; fourth premium, $10.

For exhibit of 15 beets, weighing not less than 1 pound each, showing the highest test of sugar: First premium, $20; second premium, $15; third premium, $10; fourth premium, $5.

For exhibit of 15 beets, weighing not less than 1 pound each, showing the highest test of sugar and grown by boy 16 years of age or under: First premium, $20; second premium, $15; third premium, $10; fourth premium, $5.

For the best kept account and record showing the cost and labor performed in growing 1 acre or more of beets: First premium, $20; second premium, $15; third premium, $10; fourth premium, $5.

For paper on "Growing sugar beets for profit," containing about 1,500 words: First premium, $20; second premium, $15; third premium, $10; fourth premium, $5.

BLOOMINGTON.—The following report appeared in the columns of the Sugar Beet Gazette:

The following detailed report of the actual cost of the labor in raising 378 acres of sugar beets in this vicinity is furnished by Mr. A. G. Kingman, superintendent at this place for the Illinois Sugar Refining Company at Pekin. The report is very interesting for comparison with previous estimates of such cost, and because it is the average of a large number of acres. The estimate given below for the corresponding items of labor is that of Prof. P. G. Holden:

Cost of raising and harvesting a sugar-beet crop.

Items of work done.	Actual cost.	Estimated cost.
Clearing stalks	$0.53	$1.00
Plowing	1.23	.50
Preparing ground	1.17	1.15
Seeding	.27	.35
Bunching	2.06	1.50
Thinning	3.28	3.50
Weeding and hoeing	9.14	5.00
Cultivating	.50	2.00
Lifting	1.35	1.00
Pulling and topping	5.50	5.00
Hauling	4.68	5.00
Total	29.71	28.00
Total team work	9.73	13.00
Total hand work	19.98	15.00

It will be seen by the above that the actual cost in the aggregate was very close to the estimate. The widest difference was in the item of weeding and hoeing, which cost $9.14, while the estimate was only $5. There were special reasons for this extra cost, which could scarcely occur two seasons in succession. A wet spell, preventing work, allowed the weeds to get quite a start, and then the Bloomington fire and a circus attracted the workers from the fields until the condition required much extra hand work. The cultivators could not be used as usual at this time, and it will be seen that the cost of cultivating was only 50 cents per acre, while the estimates allowed $2.

The comparison given is on items of labor only and does not include rent of land, seed, superintendence, interest or investments, rents, and repair of tools, freight, etc. These items in the estimate are placed at $12.50.

The total cost for the hand work was $7,552.44, and for team work $3,677.94.

Lifting	$540.30
Hauling	1,591.58
Pulling, piling, and topping	2,305.39
Sundries	13.78
Superintending	374.00
Total	4,825.05

IOWA.

CERRO GORDO COUNTY.—There were nearly 200 acres of beets raised last year, and most of the product was shipped to the Minnesota Sugar Company of St. Louis Park. The farmers were beginners in beet growing, and under the circumstances did very well. The average yield was 12 tons to the acre and the best 20. The beets averaged 13.12 per cent sugar content and 84.30 purity. The people of Clear Lake, in that county, are trying to secure a sugar factory.

FORT DODGE.—The Sugar Beet Gazette says:

About a year ago the Fort Dodge Beet Sugar Company began its efforts to develop the sugar-beet industry in Webster County. Mr. Chantland, the secretary, furnishes the following figures of sums they are paying out as the result of the first year's work. These prices are net, after deducting the price of seed and rent of machinery:

Andre Chantland, Badger, 5 acres, $373.25, or $74.81 per acre.
Adolph Houge, Badger, 5 acres, $224.85, or $44.96 per acre.
J. H. Alpers, Fort Dodge, 2 acres, $116.93, or $58.46 per acre.
P. J. Shultz, Clare, 2½ acres, $120.10, or $48.04 per acre.
J. J. Rutledge, Douglas Township, 3 acres, $98.04, or $32.68 per acre.
C. L. Blaine, Douglas, 2 acres, $85.72, or $42.86 per acre.
Louis Elbert, Cooper, 2 acres, $76.60, or $38.30 per acre.
Ole Levold, Badger, 1 acre, $45.46.
O. E. Edwards, Clare, 2 acres, $81.16, or $40.58 per acre.
T. W. Thomas, Cooper, 4 acres, $33.10.
J. H. Fialo, Fulton, 3 acres, $110.76, or $36.92 per acre.
Frank Fiderlick, Elkhorn, one-half acre, $21.70.

SIOUX CITY.—The following is clipped from the same journal:

The plant of the Sioux City Beet Sirup and Preserving Company is in operation, as far as the machinery that has been installed up to date will permit. More machinery is expected, and the plant will probably be in full blast by January 1, 1902. It is now turning out all kinds of sirups and rock candy, besides jellies, jams, apple butter, and some mince-meat.

Negotiations have been completed for the establishment of the plant of the Omaha Beet Sirup and Chicory Company, at South Sioux City. The Omaha people take $80,000 of the $100,000 capital stock. The company will be incorporated under the title of South Sioux City Beet Sirup and Chicory Company.

The beet sirup manufactured by the Omaha Beet Sirup Company received the highest award at the Pan-American Exposition at Buffalo, the prize being a gold medal for its excellence. This award was received in competition with other sirups, such as cane, maple, and sorghum sirups from all parts of the country. The officers of the company, including Manager Peterson, are proud of the showing made by the product of the Omaha factory.

IDAHO.

The State of Idaho passed a beet-sugar bounty law, which was signed by the governor.

MICHIGAN.

The following on "Sugar-beet examination in Michigan" was written by P. F. Trowbridge, of the University of Michigan:

At the different beet-sugar factories in Michigan two methods are used for finding the amount of tare (dirt adhering to the beets).

First method.—A half bushel of beets is taken from each wagon or car as a sample, satisfactory to both the farmer and the factory representative. From this sample 20 to 25 pounds are carefully weighed. These beets are then well brushed with bristle brushes, and retopped if the whole of the crown has not been removed. The beets are again weighed, and the loss in weight computed to per cent is reported as the amount of tare.

Second method.—The weighed sample is washed in a revolving washer, allowed to drain for a few moments, retopped if necessary, and again weighed. The loss in weight is reported in terms of percentage. The second method requires less labor, and is more rapid. It is also more nearly in accord with the factory operation. The first method fails to remove every particle of dirt, but does remove many small rootlets and a small amount of the outside of the beets, especially if they have been frozen.

In the second method the adherent water tends to decrease the amount of tare. In the following series of experiments, made at one of the Michigan factories, care was exercised to make both samples from each load as representative as possible.

Methods of determining the tare compared.

Number of sample.	Tare by first method.	Tare by second method.	Difference.
	Per cent.	*Per cent.*	*Per cent.*
1	8.75	6.25	2.50
2	10.00	8.75	1.25
3	13.75	13.75	0.00
4	7.50	7.50	0.00
5	5.00	6.25	1.25
6	21.25	22.50	1.25
7	8.75	6.25	2.50
8	10.00	7.50	2.50
9	11.25	11.25	0.00
Average	10.14	10.00	.14

The following comments concerning developments at various points in Michigan are taken from issues of the Sugar Beet Gazette:

BAY CITY.—It has been decided to erect a plant at Bay City for the purpose of utilizing the molasses from a number of sugar factories. The Saginaw Sugar Company is interested in the enterprise. Just what is to be produced from the molasses has not been learned. Carman N. Smith, of Minneapolis, is promoting the deal.

The Michigan Chemical Works, which is to use the residue molasses from the sugar factories, will begin operations in a few days. The company has forty tank cars of 7,000 gallons capacity each, which will bring the molasses from the various factories. From the molasses alcohol and potash will be made.

CARROLLTON.—The Valley Sugar Company have begun work on their sugar plant and are building what they claim to be the most extensive beet sheds in the world, which are to have a capacity of 15,000 tons.

LANSING.—Since the beet-sugar factory at Lansing has become an assured fact a large number of neighboring farmers are plowing up their wheat, which is said to be in bad condition, and are planting the ground to sugar beets.

A consignment of 4,200 sheep have reached Lansing, which will be fattened on the beet pulp turned out by the Lansing Sugar Company. The sheep are the property of W. H. Gilbert, of Bay City, and L. S. Boutell, of Lansing. Pens have been prepared at the sugar factory, and about 300 will be placed in each pen. Students from the agricultural college will have charge of each pen, to assist in feeding, weighing, and otherwise caring for the sheep, and the work will be done in a systematic man-

ner, all the details and results being carefully noted, so that an accurate record may be had in the spring of the development of these lambs. Silos have been erected at the Lansing factory at a cost of $4,000, and all the conditions for a successful experiment have been carefully arranged so that the results in the spring should prove of value in determining the efficiency of sugar-beet pulp as a feed.

The farmers are beginning to appreciate the value of pulp for feeding purposes. They are eagerly taking it from the factory, and a number of cattle feeders in the vicinity are hauling away large quantities, having found its effects on their stock most beneficial.

SAGINAW.—The farmers are now drawing considerable sugar-beet pulp from the Saginaw Sugar Company's factory and will use it for feeding stock. Those who have experimented with the product pronounce it excellent for fattening purposes, and it is now believed that it will be used extensively by growers who are raising stock for market.

MONTANA.

Governor Toole, of Montana, vetoed the bill which proposed a bounty of one cent a pound on beet sugar produced in the State, and limiting the bounty to $40,000.

HAMILTON.—B. McGinty, superintendent of the Daly Bitter Root farm, of Hamilton, in an interview in the Anaconda Standard, said:

At present the experiment of raising sugar beets is being conducted, and if the tests are satisfactory and the land found suitable, it may be that the farm will be converted into a big sugar-beet plantation, and a refinery built to work the crop into the finished product. The experiments going on are rather expensive, but I don't suppose they are anything to what will be done should the growing of sugar beets prove successful. At present there are fifteen different patches of beets, which are being cared for by an expert in that line. Every patch is composed of a different soil, and in this way the best results will be obtained. From what I have heard, and from my own personal observation, the beets are doing fine, and there is no reason why that section of the country should not become an important factor in the beet-sugar industry. One peculiarity in the experiments is the evident good results obtained from all the various soils.

NEW YORK.

BINGHAMTON.—The capacity of the factory of the Binghamton Beet Sugar Company is being increased to 600 tons. Work is well along and beet slicing is expected to begin early in October.

ROME.—The factory at this place has reached the end of its career, as is shown in the following item from the Sugar Beet Gazette:

The real property of the first New York beet-sugar factory at Rome was sold at receiver's sale January 17. The purchasers were F. B. Smith and S. M. Stevens, representing the bondholders. The figure accepted was $18,000.

The machinery, boilers, and fixtures were sold for the bondholders to Hans Brumn, of Kiehl, Germany, who intends to ship them to North Dakota and utilize them in fitting out a dextrin factory.

OHIO.

FREMONT.—The Continental Sugar Company, in addition to a larger crop of its own than last year, purchased the beets which were grown for the Illinois Sugar Refining Company, at Pekin, Ill. The factory

has erected additional beet sheds, and has now ample accommodations for all the beets that may be received.

UTAH.

LEHI.—At a recent meeting of the directors of the Utah Sugar Company it was decided to increase the capital stock of the corporation from $1,000,000 to $2,000,000.

One-half of the money to be raised from the new issue, $500,000, will be used immediately in paying for the Bear River Canal and the 30,000 acres of land under it recently purchased for the sugar company by Manager T. R. Cutler. The rest will be retained in the treasury, it being the intention to erect, at some future time, a new factory in the Bear River Canal country, possibly near Corinne.

WASHINGTON.

WAVERLY.—Beet pulp from the sugar factory at Waverly is being successfully used to fatten 300 beef cattle on the stock farm of W. E. Mann, near that town. Mr. Mann says:

I am feeding 300 head of 3 and 4-year-olds most successfully on the pulp. The cattle consume on an average nearly 100 pounds each per day, in addition to hay. The animals are putting on flesh in fine shape—better than 3 pounds a day.

The pulp from the beet-sugar factory is excellent feed. It can be kept in an ordinary silo, and is good feed for a year, and with care can be kept two years.

I secured the stock I am now fattening from Okanogan County. I expect to begin selling in about thirty days, when the animals will be in prime condition. This is the first season I have experimented with beet pulp as fodder. So far there is every indication of success.

The beet pulp from the sugar factory is sufficient to fatten annually 1,000 head of cattle. I have now ready 250 head of fat steers which have been fed on the pulp. The experiment has been most satisfactory. I find it necessary to use straw and hay in small quantities with the pulp, and a little grain is good to top off with at the end of the feeding season. I anticipate there will be many cattle fattened next fall and winter on the beet-sugar pulp.

WISCONSIN.

BEAVER DAM.—Quoting again from the Sugar Beet Gazette:

Many growers who contracted for only 2 acres say they will cultivate 10 next season. Messrs. A. E. Barker and C. C. Groose, who went to Michigan as delegates for the farmers here to look over the fields in that State, are enthusiastic about beet culture. These gentlemen have each contracted for 20 acres this year, but they will increase their acreage to 40 next season.

Most the bunching and thinning was done at a cost of $7 to $8 per acre, and strict attention to instructions was paid by the workers.

IN GENERAL.

The following items of general information are clipped from recent issues of the Sugar Beet Gazette:

Sugar syndicates which manipulate the European market predict that the United States will produce all the sugar it needs, according to United States Consul

Dornelmann, at Prague, in a communication to the Department of State. It is shown that Russia, Germany, France, and England materially increased their consumption of sugar last year, while Spain, Italy, and the Balkan States have produced not only all the sugar needed at home, but are exporting to a small extent. Even Egypt, which recently was obliged to import about 50,000 tons annually from Austria, now exports large quantities to the United States and India. With reference to beet sugar the consul says that it is a surprising fact that the United States, with millions of acres of virgin soil and improved machinery, has such a comparatively small acreage planted in sugar beets and so few sugar factories.

The American Beet Sugar Company reports for the year ended December 31 last:

Sugar produced.....pounds..	33,351,500
Total credit.....	$1,931,707
Total cost of operating.....	1,166,240
Freight on sugar.....	97,301
Total.....	1,263,541
Total profit from operation.....	668,166
Total cost of maintenance.....	242,530
Balance.....	425,636

Among the principal items of the balance sheet of December 31 are: Treasury stock, $1,000,000; cash on hand, $97,458; estimated value of sugars on hand, $229,000. The estimated surplus account for the fiscal year ending June 30, 1901, shows: Total credits of campaign $511,363, loss $85,728; net factory profits of campaign, $425,635, less general expense and interest, $130,000; balance, $295,635, less preferred dividends, $240,000; net profits, $55,635.

A résumé of the output of beet and cane sugars in European countries may be made as follows:

Output of beet and cane sugars in Europe.

Country.	1898–99.	1899–1900.	1900–1901.
Beet sugar:	*Tons.*	*Tons.*	*Tons.*
Austria	1,042,000	1,099,000	1,070,000
Germany	1,720,000	1,791,000	1,900,000
France	782,000	919,000	1,070,000
Russia	755,000	898,000	900,000
Belgium	209,000	270,000	320,000
Holland	150,000	170,000	170,000
Denmark	40,000	41,000	50,000
Sweden	60,000	81,000	110,000
Roumania, Italy, and Spain	40,000	110,000	160,000
Total	4,798,000	5,379,000	5,750,000
Cane sugar	2,654,000	2,442,000	2,907,000
Grand total	7,452,000	7,821,000	8,657,000

The results that will be obtained from beets containing 12 per cent sugar under varying purities in the same factory and by the same process of manufacture are shown in the following table:

Variance in proportions of molasses and sugar.

Sugar in beet.	Purity co-efficient.	Molasses.	Sugar.
Per cent.		*Per cent.*	*Per cent.*
12	70	5.12	6
12	72.5	4.45	6.67
12	75	3.82	7.29
12	77.5	3.25	7.87
12	80	2.70	8.42
12	82.5	2.19	8.93
12	85	1.70	9.42
12	87.5	1.24	9.88
12	90	.80	10.32

FORMS OF CONTRACTS.

Below I give the forms of two contracts, one made by a sugar company with the farmers growing beets, and the other by a sugar company with laborers hired by it to grow beets on its own land.

These contracts are given as typical of such agreements where sugar-beet factories are established. The first shows the requirements of the factories, the scale of prices paid for beets, etc. The second gives an idea of the work performed by the laborer, and what he receives per acre for such work. He is supposed to perform all the labor necessary in growing a crop of beets, except that which must be performed with a team in plowing, cultivating, and delivering the beets to the factory.

CONTRACT BETWEEN SUGAR COMPANY AND FARMER.

This agreement made and entered into this —— day of ———, 190–, between ———— (a corporation), the first party, and ——— ———, of ————, second party, witnesseth:

That the first party agrees to purchase from second party any and all beets he may grow from seed that may be sown by the first party on the ——— acres of land hereby agreed upon, that do not weigh over three and one-half pounds each, to be delivered by the said second party as required by first party at the following prices and on the following conditions and not otherwise, to wit: For any and all beets that may be ordered by the first party from second party during the months of September and October, 1900, the said first party will pay the said second party on the 15th of each month for all beets that have been delivered during the preceding month the sum of $4.50 per ton.

The first party further agrees that during said months of September and October it will take at said price from said second party any and all beets grown upon said land that have an average polarization of not less than 14 per cent saccharine and 80 per cent purity, provided said beets are delivered in a proper manner under first party's direction, in the sheds of the said first party, at ———, or on cars at ———, at option of first party, at cost of second party, in first-class condition, with the tops closely and squarely cut off at the base of the last or bottom leaf. The beets so delivered shall reach all the requirements of this agreement, and not contain any diseased, frozen, damaged, or improperly topped beets, nor any beet that weighs over three and one-half pounds, otherwise the entire load so being delivered may be rejected. The dirt weighed with the beets shall be tared and deducted from the gross weight by the first party in its customary manner and shall be conclusive. In

case any part of said beets are not ordered, or if any part of patch has been stopped because of the polarization not holding up to the standard as per this agreement before the first day of November, A. D. 1900, then first party agrees with second party that it will purchase any and all beets not so ordered or delivered on and after said first day of November, 1900, and until and including the 30th day of November, 1900, that may be raised on the said land as aforesaid that polarize not less than 12 per cent saccharine with 80 per cent purity, and no others, at the following average polarizations and following prices per ton, to wit:

Saccharine	Purity.	Price.
Per cent.	*Per cent.*	
14	80	$4.50
13	80	4.25
12	80	4.00

For all beets delivered, payments to be made on the 15th day of the succeeding month thereafter. After the 30th of November, 1900, it shall be optional with the first party whether or not it accepts any beets that have not been delivered. The second party hereby agrees to prepare said land in first-class condition for the planting of said beet seed, cultivate and harvest in a husbandlike manner ——— acres of sugar beets on the land agreed upon, and protect them from the frost and sun while being harvested and delivered, and to deliver them at the times and places, and in the manner set forth in this contract for the prices above named, to be paid as above set forth; and further agrees to pay the first party the sum of $2.75 per acre for the furnishing of the seed and planting the said land, which may be done by the first party as fast as circumstances will permit.

To ascertain the quality of said beets the first party shall, at various times during the growing and harvesting season of 1900, also at times of delivery, sample and polarize in its usual manner.

During the month of November, 1900, not less than ten average beets per acre shall be taken by the first party to ascertain the value of all beets that have not been ordered, and shall be conclusive. During the month of November the second party may deliver beets as fast as they may desire if the said beets reach the requirements of the contract.

This contract is personal and not transferable.

——— ———,

——— ———.

CONTRACT BETWEEN THE SUGAR COMPANY AND THE FARM LABORER.

This agreement, made and entered into, in duplicate, this —— day of ———, A. D., 190–, by and between ——— Beet Sugar Company, party of the first part, and ——— ———, party of the second part,

Witnesseth, That for and in consideration of the promises and agreements hereinafter set forth, said first party has hired and employed said second party, and said second party has agreed and does hereby agree to bunch, thin, hoe, keep free from weeds and in a first-class condition, satisfactory to said first party or to its agent, until such time as the crop shall be ready for laying by, and then when directed to harvest said crop, then to pull, top, and pile together, all to be done as instructed, ——— acres of sugar beets near ———, County of ——— and State of ———, and being on section ——, township ——, range ———.

In consideration of faithful performance by said second party, as hereinbefore set forth, said first party has agreed to and will pay to said second party, from time to time as earned, the several sums following:

$6 per acre after the bunching and thinning of beets.
$4 per acre when the entire summer's work is done.
$2 per acre when the harvesting is commenced.
$6 per acre when the balance of the work has been done and the harvest is completed, which time will be not earlier than November —— next.

For each ton of beets above an average of ten tons per acre raised by party of the second part under this contract, the party of the first part agrees to pay to party of the second part the sum of 50 cents per ton as a bonus over and above the contract price per acre.

It has been further expressly agreed that in case said second party fails in any way to do and perform as he has agreed to do, that then and in such case said second party hereby expressly consents that said first party may hire such work to be done as may be necessary to do as said second party has undertaken to do, and as against this contract charge up said charges, the difference, if any, accruing to said second party to be paid to him, or in case of any deficiency he agrees to pay the same to said first party on demand, and during the term of this contract he expressly grants to said first party and its employees the right to the full and entire possession of the premises where said sugar beets are grown.

——— ———
——— ———

In presence of:

——— ———

PRICES PAID AT DIFFERENT FACTORIES.

The following sections are taken from different printed contracts between the companies and the farmers and indicate the various prices paid for beets by the different companies:

All sound beets to be bought and paid for by said factory at the following rates, viz:

All beets containing fourteen (14) per cent of sugar or less, four ($4) dollars per ton, and an additional twenty-five (25) cents per ton for each and every one (1) per cent of sugar above fourteen (14) per cent, fractions in proportion.

An additional sum of twenty (20) cents per ton will be paid for each and every ton of beets siloed, when delivered at the factory, after November 15th.

Beets to have the tops squarely cut off so as to remove the entire portion on which leaves have grown, and to be subject to the usual tare for dirt and improper topping.

For beets containing 12 per cent of sugar and under 13 per cent to the weight of the beets, $4.25 per ton of 2,000 pounds; 13 per cent and under 14 per cent, $4.58⅓; 14 per cent and under 15 per cent, $4.91⅔; 15 per cent and under 16 per cent, $5.25, and 33⅓ cents per ton for each additional full 1 per cent of sugar content. All beets to have a coefficient of purity of 80 or more.

For any and all beets furnished and delivered in accordance with the provisions of this contract the first party agrees to pay the sum of $4.50 per ton, such payment to be made on or about the 15th day of each month for all beets delivered during the previous month.

And the said party of the first part agrees to pay to the party of the second part for all beets delivered at its factory as follows:

For beets containing 12 per cent of sugar to the weight of the beet, and under 16 per cent, $4 per ton of 2,000 pounds; for beets containing 16 per cent of sugar to the weight of the beet, and under 17 per cent, $4.33⅓ per ton; for beets containing 17 per

cent of sugar to the weight of the beet, and under 18 per cent, $4.66⅔ per ton; for beets containing 18 per cent of sugar to the weight of the beet, and under 19 per cent, $5 per ton; and 33⅓ cents additional advance per ton for each and every per cent thereafter.

Should any of the beets contain less than 12 per cent of sugar to the weight of the beet, and 78 per cent purity, the price paid per ton will be $3 for all such beets accepted at the factory; but the said first party reserves the right to accept at its factory only such beets as it may deem fit for manufacturing purposes.

For any and all beets furnished and delivered in accordance with the provisions of this contract, the first party agrees to pay the sum of four dollars and fifty cents ($4.50) per ton, such payment to be made on or about the fifteenth day of each month for all beets delivered the previous month.

Said first party shall pay said second party the sum of $4 per ton for the same; provided, however, said beets shall contain not less than 12 per cent nor more than 14 per cent sugar to the weight of beet, with a purity coefficient of 80.

FEEDING SUGAR-BEET PULP IN EUROPE.

I inclose a copy of the report made by United States Consul Baehr, at Magdeburg, Germany, on the "Rations for cattle and sheep with sugar-beet pulp."

Probably in no other country in the world has the feeding of beet pulp been studied and tested more extensively or scientifically than in Germany. This report will be very interesting at this time as giving the conclusions reached after years of experience.

The metric system is used throughout, weights being given in kilograms. After each item I have inserted in parenthesis the equivalent in pounds.

In the headlines introducing each of the various food rations, the consul gives the number of pounds of "dry matter" entering into the ration. This refers to the ration free from moisture. In the ration itself the weight given to each item refers to the food with its natural moisture.

RATIONS FOR CATTLE AND SHEEP WITH SUGAR-BEET PULP.

There is no difference between the results of feeding fresh pulp and that which has been stored in a silo. Both kinds have the same effect and are therefore used in equal quantities. The difference between them is that, according to the manner of storing, from 15 to 30 per cent of the substance is lost by the storing in the silos.

In the following tables moist pulp is referred to:

I. Draft oxen with fair amount of work.

Food requirements per 1,000 kilograms (2,200 pounds) live weight, per day 25 kilos (55 pounds) dry substance, containing about—

2.0 kilos (4.4 pounds) protein.
0.5 kilos (0.11 pounds) fat.
11.5 kilos (25.3 pounds) carbohydrates.

Ration recommended:	Kilos.	Equivalent in pounds.
Fresh pulp	60	132
Meadow hay	6	13.2
Summer straw	5	11
Winter straw	5	11
Malt sprouts	2	4.4
Cotton-seed cake	2.5	5.5
Ration for same with less work:		
Fresh pulp	40	88
Winter straw	8	17.6
Pulse chaff	12	26.4
Cotton-seed cake	1.5	3.3

II. Dairy cows.

Food requirements per 1,000 kilos (2,200 pounds) live weight, per day about 27 kilos (59.4 pounds) dry substance, containing—

2 kilos (4.4 pounds) protein.
0.4 kilos (8.8 pounds) fat.
11 kilos (24.2 pounds) carbohydrates.

Rations recommended to produce from 7.5 kilos (16.5 pounds) milk daily:		Equivalent in pounds.
No. 1.—		
Fresh pulp	30	66
Clover hay	5	11
Meadow hay	5	11
Oat straw	5	11
Wheat chaff	3	6.6
Malt sprouts	2	4.4
Oat bran	1	2.2
Palm-seed flour	2	4.4
Rice-seed flour	1.5	3.3
Meal flour	.5	1.1
No. 2.—		
Fresh pulp	40	88
Lucern hay	5	11
Clover hay	3	6.6
Meadow hay	4	8.8
Winter straw	8	17.6
Rye bran	1	2.2
Coarse wheat bran	2	4.4
Cotton-seed cake	.5	1.1
No. 3.—		
Fresh pulp	50	110
Clover hay	6	13.2
Meadow hay	5	11
Summer straw	4	8.8
Linseed cake	2	4.4
Sesame flour	1.5	3.3
Winter straw	3	6.6

Rations recommended to produce 10 kilos (22 pounds) of milk daily per 1,000 kilos (2,200 pounds) live weight per day, about 29 kilos (63.8 pounds) dry matter containing—

2.5 kilos (5.5 pounds) protein.
0.5 kilos (1.1 pounds) fat.
14.4 kilos (31.6 pounds) carbohydrates.

Rations recommended to produce 10 kilos (22 pounds), etc.—Cont'd.

No. 1.—	Kilos.	Equivalent in pounds.
Fresh pulp	35	77
Meadow hay	4	8.8
Clover hay	6	13.2
Oat straw	4	8.8
Wheat chaff	3	6.6
Moist beer grains	20	44
Malt sprouts	2	4.4
Rape-seed cakes	2.5	5.5
No. 2.—		
Fresh pulp	45	99
Clover hay	9	19.8
Summer straw	6	13.2
Winter straw	3	6.6
Wheat chaff	2	4.4
Peanut cake	2.5	5.5
Palm-seed cake	5	11

III. Fatted cattle.

Food requirements per 1,000 kilos (2,200 pounds) live weight per day, 30 kilos (66 pounds) dry matter containing—

3 kilos (6.6 pounds) protein.
0.7 kilos (1.54 pounds) fat.
14.5 kilos (31.9 pounds) carbohydrates.

Ration recommended:

	Kilos.	Equivalent in pounds.
Fresh pulp	50	110
Clover hay	6	13.2
Lucern hay	6	13.2
Barley straw	6	13.2
Moist beer grains	20	44
Bruised corn	3	6.6
Peanut cake	1	2.2

IV. Fatted sheep.

Food requirements per 1,000 kilos (2,200 pounds) live weight, per day, about 28 kilos (61.6 pounds) dry matter containing:

3.5 kilos (7.7 pounds) protein.
0.6 kilos (1.32 pounds) fat.
14.5 kilos (31.9 pounds) carbohydrates.

Rations recommended:	Kilos.	Equivalent in pounds.
Fresh pulp	50	110
Lucern hay	12	26.4
Straw	8	17.6
Rye flour	5.5	12.1
Rape-seed cakes	4	8.8

V. Growing cattle.

Six to 8 months old, weighing about 250 kilos (550 pounds), daily fodder to contain about 6.3 kilos (13.86 pounds) dry substance with

0.63 kilos (1.386 pounds) protein.
0.2 kilos (4.4 pounds) fat.
3.4 kilos (7.48 pounds) carbohydrates.

Rations recommended:	Kilos.	Equivalent in pounds.
Fresh pulp	10	22
Meadow hay	4	8.8
Summer straw	2	4.4
Oats	1	2.2
Sesame cake	.5	1.1
Linseed	.13	.286

For same, age about 12 to 18 months, weight about 340 kilos (748 pounds), daily rations to contain per head about 8.2 kilos (18.04 pounds) dry substance with

0.7 kilos (1.54 pounds) protein.
0.2 kilos (0.44 pounds) fat.
4.2 kilos (9.24 pounds) carbohydrates.

Rations recommended:	Kilos.	Equivalent in pounds.
Fresh pulp	10	22
Meadow hay	4	8.8
Summer straw	3	6.6
Oats	1	2.2
Malt sprouts	.5	1.1
Palm-seed cake	.5	1.1
Sesame cake	.25	.55

VI. Growing sheep; age, 8 to 11 months; weight, 46 kilos. (101.2 pounds).

Food requirements per 100 sheep per day about 111 kilos. (244.2 pounds) dry substance, with—

14 kilos. (30.8 pounds) protein.
2.5 kilos. (5.5 pounds) fat.
66 kilos. (145.2 pounds) carbohydrates.

Rations recommended:	Kilos.	Equivalent in pounds.
Fresh pulp	100	200
Meadow hay	50	110
Pulse chaff	20	44
Oat chaff	10	22
Linseed	15	33
Rape-seed cake	15	33
Rye flour	10	22
Wheat flour	10	22

CONTRIBUTIONS FROM THE BUREAU OF PLANT INDUSTRY.

PREPARED UNDER THE DIRECTION OF B. T. GALLOWAY, CHIEF.

LETTER OF SUBMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF PLANT INDUSTRY,
Washington, D. C., March 27, 1902.

SIR: I herewith submit for publication as part of the report on the beet-sugar industry a paper on "Some diseases of the sugar beet," by C. O. Townsend, and a paper on "Sugar-beet seed: Production and testing," by A. J. Pieters. Both papers were prepared under my direction, the writers being members of the force employed in this Bureau.

Respectfully,

B. T. GALLOWAY,
Chief of Bureau.

Hon. JAMES WILSON,
Secretary.

SOME DISEASES OF THE SUGAR BEET.

By C. O. TOWNSEND, of the Bureau of Plant Industry.

INTRODUCTORY.

Owing to the rapid extension and development of the already important sugar-beet industry in the United States, and in view of the enormous losses that have been sustained by the sugar-beet growers during the past several years through the agency of plant diseases, the Office of Vegetable Physiology and Pathology has begun a special study of these diseases for the purpose of determining the most practical means by which the losses from this source may be avoided. In accordance with this plan, this work was taken up at the beginning of the present fiscal year and it is the object of the writer at this time to consider briefly the most important diseases of the sugar beet that have come to his attention during the past season, together with some of the problems that these diseases present to the practical grower, viz, the suppression or control of the fungous diseases and other

influences unfavorable to the production of sugar beets. Most beet growers in all sections of the country, even in those sections where the beets have been grown but a few seasons, realize that a proper understanding of the nature and treatment of the diseases of the sugar beet is necessary to the attainment of the best results in the production of this crop. While this is true, there are growers in nearly all sections who have not yet learned to distinguish, in all cases, between the normal and the abnormal beet.

There is no time in the life of the beet when it is not subject to attack from one or more forms of disease. The disease may be produced by unfavorable conditions of soil or climate, or by an attack of some parasite upon or in some part of the beet. It not infrequently happens that unfavorable conditions of weather and soil combine with parasitic attacks to produce disease. These fungous diseases may result in the entire destruction of the crop on the area affected, or the beets may continue to live but be greatly reduced in size or quality or both, causing a heavy loss in tonnage and in the yield of sugar. Any condition which interferes with the proper development of the leaves, either by reducing their size or by prematurely destroying them, in whole or in part, tends to reduce the sugar content of the beet, both directly and indirectly; directly, because all sugar is first formed in the leaves under the influence of heat and light; and indirectly, because, when the leaves are injured or destroyed, the tendency is for new leaves to be formed, and this takes place at the expense of the sugar stored in the root. The root acts only as the storehouse for the sugar and plays no part directly in its production.

Three conditions especially harmful to the sugar beet are drought, excessive moisture, and alkaline soils. A deficient supply of moisture in the soil at any time during the growing season often permanently injures the plants so that their normal development is impossible. The earlier in the life of the plant that this injury is produced, the more harmful are its results. It seems to be practically impossible for beets to recover entirely from a serious injury of this kind. On the other hand, excessive moisture in the soil may result in an abnormal development of the top at the expense of the size or quality of the root, or even in the decay and death of the plant. This latter result is often hastened by the action of parasitic fungi, especially if an excessively wet period follows a period of marked dryness. Although the sugar beet is capable of withstanding the effects of a larger percentage of alkaline substances in the soil than most of the other economic plants, there is a limit beyond which the health of the plant is seriously affected, especially during the early stages of growth.

The most destructive parasites on the beet are insects, fungi, and bacteria. Insects may be injurious to the beet directly by attacking some part of the plant; indirectly, by acting as carriers of fungous

spores or bacteria, or by so injuring the leaves or roots of the beet that fungi and bacteria find ready entrance into the tissues of the plant. It is claimed by some investigators that nearly all the attacks of certain forms of fungi are preceded by injuries produced either mechanically, as in the operations of cultivation, or by insect bites. In their direct influence upon plants insects are treated from the standpoint of entomology, and therefore will not be considered in this connection.

The diseases of the sugar beet that have done the most serious damage during the past season (1901) are the following: Damping off; curly top or blight, sometimes called Western blight, bacteriosis, or California beet disease; leaf spot, leaf rust, leaf scorch, crown rot, root rot, scab, and gall, or crown gall. Other diseases have done more or less damage, but as a rule they have been somewhat local and less serious in their results than those mentioned. It should be stated in this connection that considerable work along the line of sugar-beet diseases is now in progress under the direction of the United States Department of Agriculture, the results of which are not yet ready for publication. In addition to the work that has been undertaken by the writer, some important investigations are being carried on by Mr. George G. Hedgcock, of Lincoln, Nebr., a scientific aid in the Bureau of Plant Industry. The results of these investigations will be made public as soon as definite practical results are reached.

DAMPING OFF.

During the past season one of the most potent factors in producing loss and inconvenience to the beet growers in many beet-growing sections was the so-called damping off of the young plants at or below the surface of the ground soon after they came up and before they reached their first cultivation, or even before they were thinned. The cause or causes of this disease are not definitely known. It may be due to a so-called damping-off fungus, or it may be due to unfavorable conditions of soil or weather. Unfortunately the work was begun too late last season to determine these points. In any case, the leaves of the seedlings turn yellow, the roots take on a brownish color, and the plants soon fall over and die. It is difficult to know just when the disease begins its attack, but there is reason to believe that the seedlings are often attacked before they have broken through the ground. This is especially true in those sections of the country where the soil is of such a nature that it forms a crust on the surface after the seeds are planted and before they have had time to come up, or even after the young seedlings are up. In such cases fungi need play no part in the destruction of the plants, and often no fungi are found in connection with the dead or injured seedlings. In other beet-growing areas where the soil is such that a crust does not readily form, we frequently

find the young plants dying off. This may be due to a lack of moisture or to the influence of parasitic fungi. Hence, we see that several very different causes may produce the damping-off effect. In case a soil crust is formed it should be broken up as soon as possible. For this purpose the harrow is probably the best implement to use. It should be just heavy enough to break the crust, without doing serious injury to the young seedlings that may have already formed under the crust. Perhaps the weeder will be found useful for this purpose. Some growers use a roller, while others use an ordinary drag. The former is liable to crush or bruise the young plants, while the latter may pull the seedlings out of the ground. Some writers recommend the use of fertilizers, such as phosphorus and lime, to prevent the formation of the soil crust.

If a damping-off fungus proves a serious pest it must be avoided either by crop rotation or by the treatment of the seed or of the soil with a fungicide. In this connection it should be stated that a failure to get a stand is sometimes due to too deep planting. No fixed rule can be given for the depth of planting in all the different conditions of soil in the various beet-growing sections, but experience seems to teach that the seed should not be covered to a greater depth than 1½ inches.

CURLY TOP OR BLIGHT.

This disease, apparently known under different names in different parts of the country, has done more damage, especially in the West and middle West, than all other diseases combined. In regard to the distinguishing characteristics of this disease there is more or less confusion, which arises chiefly from the fact that the various abnormal appearances accompanying the blight may be produced by one of several causes. In general, however, it may be stated that the blighted beets are stunted in growth; the outer leaves die off; the new leaves produced are small, curled or blistered in a peculiar manner; roots more or less woody and provided with numerous fine side roots, giving the beet a whiskered appearance (Pl. XII, fig. 1), while a cross section of the main root shows a more or less intense darkening of certain sets of fibrovascular bundles as soon as the beet is cut. (Pl. XII, fig. 2.) These bundles are arranged in rings within the root, hence the darkened spots seem to be arranged in rings. As already suggested, several causes may conspire to produce a stunting of the beet or a dwarfing and curling of the top. Likewise, several factors may cause the root to assume a woody texture and to produce a darkening of the fibrovascular bundles. Hence, the symptoms mentioned above may or may not be characteristic of the curly top or blight. It is possible that several forms of disease are represented by these characters, or that this disease, so strikingly similar in different sections

of the country, may, under different conditions, be due to different causes. These points can be settled only by further investigation.

Several seasons ago the Spreckels Sugar Company of San Francisco asked a number of prominent specialists in Germany and elsewhere to investigate this disease which they designated as the California beet disease. The results of these investigations were compiled and published by Professor Linhart, with his own views on the subject. The conclusion reached by these investigators in regard to the cause of this peculiar disease varied within wide limits. By some it was thought to be due to hot winds, others concluded that it was due to the action of bacteria, still others considered it the result of thread-like fungi in the leaves or in the crown, while others still thought it due to a condition of the soil, principally insufficient moisture or lack of proper or sufficient food.

At the request of the American Beet Sugar Company, Mr. N. B. Pierce, in charge of the Pacific coast laboratory of the United States Department of Agriculture, investigated the blight in California with a view to determining the cause of the trouble and its remedy. Mr. Pierce arrived at the conclusions expressed in the accompanying letter addressed to the American Beet Sugar Company, and herewith reproduced with the consent of the author:

SANTA ANA, CAL., *June 17, 1901.*

The AMERICAN BEET SUGAR CO.,
San Francisco, Cal.

GENTLEMEN: In pursuance of my expressed design, I mail you herewith a brief opinion relative to the nature and control of the blighting or stunting of beets. The views expressed are not of necessity conclusive in an investigation of this nature, but present my present opinions based upon the field and laboratory work to date. They are offered for free criticism, in hope I may thus learn their weak points and pursue future studies along the seemingly most productive lines.

(1) I consider that one of the most fundamental sources of trouble in the present system of beet culture in California is found in the use of seeds from beets not thoroughly bred or acclimated to the California climate and its arid conditions. Transpiration is too free under clear skies.

(2) Field work leads to the opinion that insufficient, or too easily or too rapidly lost, moisture of the subsoil is directly responsible for the stoppage in the growth of the taproot and the stunting or blighting of beets where other conditions may be satisfactory.

(3) General fertility of the soil is essential, together with proper culture.

(4) I have found no parasites—bacteria, higher fungi, or insects—which appear directly responsible for the blighting of the beets.

(5) The greatly increased number of basal lateral roots, and the correspondingly elongated root hairs of some blighted beets, may be laid to, or are a natural consequence of, a check in the elongation of the taproot and its normal terminal absorbent laterals.

(6) The downward growth of the taproot of a beet once blighted is apparently not easily renewed by surface irrigation, lateral roots commonly forming instead.

(7) The blackening of the beet I at present believe to be a purely chemical action, probably oxidation, arising as a consequence of insufficient water supply at the

FIG. 1.—A BLIGHTED BEET, SHOWING WHISKERED APPEARANCE.

FIG. 2.—CROSS SECTION OF A BLIGHTED BEET, SHOWING DARKENED RINGS.

Progress of Beet-sugar Industry, 1901.

proper and timely command of the plant. Chemists may be able to give more special information on this point.

In an attempt to prevent the "blighting" of beets, a serious effort should be made to select and breed beets suited to clear skies, and to pursue this selection for many generations of plants, or, in fact, continuously, thus to bring to bear the laws of heredity. This work should be done under the supervision of men skilled in the production of seed and in the natural sciences, and fully acquainted with the nature of our climate.

In the growing of the beet, in addition to making sure that the fertility standard of the soil is sufficiently high and that cultivation is properly done, it is essential to obtain and retain sufficient subsoil moisture to keep the taproot well supplied from the period of seed germination till the crop is gathered. To obtain the latter desideratum will tax all the resources of your field men. It is not sufficient to add water after the beet has run short at the taproot, as already mentioned. The water should be abundant and constant at the end of the taproot at all times, and should increase in amount below rather than above that point, so that the root is constantly supplied and led downward.

Very sincerely, yours,

NEWTON B. PIERCE,
Pathologist in Charge.

After a careful examination of what is apparently the same disease in the middle West, the writer arrived independently at the same conclusion as Mr. Pierce, viz, that the principal cause of the disease is lack of water supply to the taproot. The following instance will illustrate this point: In some beet-growing sections of the middle West there was considerable blight in 1900, while in those same sections there was little or no blight in 1901. In 1900 a very wet spring was followed by a very dry period extending over several weeks, which in turn was followed by excessive rainfalls, while in 1901 the rainfall was sufficiently uniform to give to the beets a steady and constant growth. The control of the water supply, except in irrigated sections, is not practical, yet much may be done by cultural methods in conserving the moisture in the soil. It is very essential that the beets should always maintain a steady growth from the time of germination to the ripening season. It is possible that this trouble may be overcome by the selection of beets apparently resistant to the disease, since some apparently healthy beets are found in nearly all badly diseased fields. Arrangements have been made for saving the seed from healthy beets on badly diseased fields with a view to originating varieties not subject to the disease.

LEAF SPOT.

Leaf Spot (*Cercospora beticola*) was very generally present to a greater or less degree in the Middle and Eastern States and ranked second in point of destructiveness during the past season. Very few fields examined in the sections mentioned were entirely free from it and many were seriously affected, causing considerable loss in tonnage as well as in the quality of the beets, the diseased beets having a lower

sugar content and a lower coefficient of purity. Leaf Spot is produced by a distinct and well-known fungus, *Cercospora beticola*, which attacks the leaf blades and petioles, producing brown spots with somewhat purple edges. These spots are at first small and nearly round, but increase quite rapidly in size, and when two or more spots meet, an irregular dead brown spot is produced, which is brittle and which often breaks and falls away (Pl. XIII). Eventually the whole leaf becomes affected and dies. The outer or older leaves are attacked first, and, as they die, new leaves are put out from the center of the crown. The result of this process is that the crown tends to elongate and to assume somewhat the appearance of a pineapple; hence the change in shape is often spoken of as the "pineapple" effect of the Leaf Spot disease. As the spots on the leaves advance in age, the surfaces become covered with a grayish coating, which consists of a large number of spores that are easily carried by the wind and other agencies from leaf to leaf and from plant to plant. When these spores lodge upon the green leaves of the beet, under favorable conditions of temperature and moisture, they soon germinate and produce new spots upon which, in turn, new sets of spores are formed, and thus the disease is spread more or less rapidly, depending upon conditions. Attacks of this fungus are frequently noticed when a comparatively dry season is followed by damp rainy weather. In some of the beet-growing sections several distinct attacks were made by this fungus last season, resulting in an enormous loss in tonnage as well as in sugar content and purity of the beets. The plants are seldom killed outright by this disease, but, in addition to the dwarfing of the beet, the elongation of the crown mentioned above greatly increases the amount of tare, since the elongated crown must be cut away in topping the beets. In some beet-growing sections, where the nature of the disease is not well understood, it is thought by some growers that the drying off of the outer leaves due to Leaf Spot is a natural process and not the result of disease. As a matter of fact, practically all the leaves should remain intact until the crop is harvested.

From the nature of the fungus that produces the Leaf Spot, as well as from the work done by Halsted, of New Jersey, and others in the treatment of the disease, it is probable that spraying frequently and thoroughly with Bordeaux mixture will prove to be an effective remedy. The Department of Agriculture has planned a number of experiments along this line to be carried out in different parts of the country, for the purpose of determining to what extent the treatment will be effective and how many sprayings will be necessary to hold the disease in check. A complete account of these and other experiments will be given later when their value has been determined. The Leaf Spot has been most serious during the past season on rather light soil, while but little injury has been produced on the stiffer soils. It is to

LEAVES OF SUGAR BEET ATTACKED BY LEAF SPOT (CERCOSPORA BETICOLA).

be inferred, therefore, other things being equal, that it would be safer to use heavier soil, providing, of course, that there is a variety of soils to select from. While we would expect the Leaf Spot to occur on those fields where the disease was prevalent the preceding season, some of the most seriously affected fields seen last year were in areas where sugar beets had not been grown before. This suggests the point that the Leaf-Spot fungus (*Cercospora beticola*) may have other host plants upon which it exists from year to year, and from which it may spread to the sugar beets as soon as favorable conditions arise, or that the fungus spores may be carried over long distances or be transported on the seed. It is apparent, therefore, that a rotation of crops will not prevent attacks of this fungus, although a proper rotation will reduce the probability of serious damage during the first season on a new area. The only sure way to avoid loss from this source seems to lie in the treatment of the plants in such manner that the fungus can not get a foothold, either by spraying the plants or in in some other way that will make the plants resistant.

LEAF SCORCH.

Considerable damage was done by the leaf scorch last year, especially in the eastern part of the United States. The nature of this disease has been investigated by Mr. F. C. Stewart, of the Geneva (N. Y.) Experiment Station.[a] The brown or black leaf margins are the first symptoms of the disease. As it advances, the young leaves at the center of the crown blacken and die, together with the blades of the older leaves. In still more advanced stages the roots show a brown discoloration. In some instances the disease kills the plant outright, but in most cases the diseased plants put out new leaves and survive throughout the season. No parasite has been found in connection with this disease, and Mr. Stewart is of the opinion that the trouble is due to a too rapid transpiration of moisture from the foliage. The result of the leaf scorch is a marked diminution in size of the affected beets, even though they apparently recover from the disease, as they seem to do in some cases. It is found, also, that the sugar content, as well as the coefficient of purity, is strikingly lower in the diseased than in the healthy beets at the harvesting season. Mr. Stewart recommends proper irrigation as a reasonably sure preventive of this trouble in those sections where irrigation is practicable, providing the disease should become destructive in the irrigated regions. In those areas where irrigation can not be practiced, beets should not be planted on light sandy soil, and in dry weather moisture should be conserved by stirring the soil frequently, and especially

[a] Bulletin 162.

[illegible] besides the predisposition to disease on sandy soil, it has been found that beets do better and produce a better [illegible] when grown on a rather stiff soil.

BEET SCAB.

The fungus producing beet scab (*Aspergillus nidulans*) attacks the root only and the diseased beets may be recognized in early stages by the presence of numerous [illegible] slightly elevated corky spots on the surface of the beet roots. These spots, at first small and nearly round, gradually increase in size until eventually they meet and form large irregular areas, sometimes almost covering the entire root, as shown in Pl. XV, which shows well the contrast between the diseased and healthy portions of the same beet. Beet scab is rather widespread, being found in many parts of the middle and eastern beet-growing States. As already indicated, this disease is due to the presence of a fine and [illegible] fungus known as *Aspergillus nidulans*, growing in the tissues of the outer layers of the beet root. This fungus was discovered in 1884 by Thaxter, who proved its causal relation to the scab disease of the potato. Since that time it has been shown by Bolley, and independently by Arthur, that the beet scab is produced by the same parasite. It is well known that *Aspergillus nidulans* will live in the soil from year to year, and it is therefore easy to reach the conclusion that beets should never follow beets or potatoes if the crop produced is in the least scabby. Repeated efforts have been made to treat the soil infested with such fungus in such manner as to destroy the parasite, but thus far there have been no satisfactory results. There is practically little danger of introducing this fungus into the soil with the beet seed, since the fungus does not attack the parts of the plant above ground. It is generally believed that this disease, which spreads rapidly and does considerable damage, may easily be avoided by a proper rotation of crops, but there is no definite knowledge, so far as the writer is aware, in regard to the length of time that this fungus will live in the soil.

BROWN ROT, OR RHIZOCTONIA ROT.

There are several forms of disease known as root rot, of which the so-called brown rot has been most general and has done the greatest amount of damage. It is spread more or less abundantly over the middle and eastern parts of the United States. This disease has been given considerable attention by Dr. B. M. Duggar, formerly of the Cornell Experiment Station,[1] now with the Bureau of Plant Industry, United States Department of Agriculture. Since the discovery of this disease several other forms of root rot have been observed; hence,

[1] Bulletin 163, Cornell Univ. Exp. Sta., Ithaca, N. Y.

SUGAR BEET SERIOUSLY AFFECTED BY SCAB.

the term root rot does not distinguish this from other diseases. It has for this reason been called the brown rot; but even this does not serve to distinguish it from other forms of disease; therefore, since it is produced by a distinct fungus, *Rhizoctonia betæ*, it is probably best to designate this rot as the rhizoctonia rot. Dr. Duggar describes this disease as follows:

> Under favorable conditions the rhizoctonia root rot generally secures its foothold at the bases of the leaves. These parts are moistened with the slightest rain or dew. Inoculation experiments show that in those regions the disease "takes" very readily. The first evidence of the attack is manifested in the blackening of these leaf bases, the outer leaves first, so that the stalks soon become unable to support the blades and the leaves may lie prostrate on the ground. The leaves do not, however, lose their green color very readily. The disease soon works into the crown and root proper, causing the infected parts to turn brown. With further spread of the fungus in the root regions cracks appear in the root (Pl. XVI), and if the conditions continue to favor the development of the disease the whole top gradually rots away and the beet finally disappears.

As a preventive of the Rhizoctonia rot, Dr. Duggar suggests the use of lime or other alkaline substance, on the theory that the fungus requires an acid medium on which to grow. The question of a satisfactory preventive has not been fully worked out, and it is the purpose of this Department to determine the nature and quantity of substances best suited to control the disease.

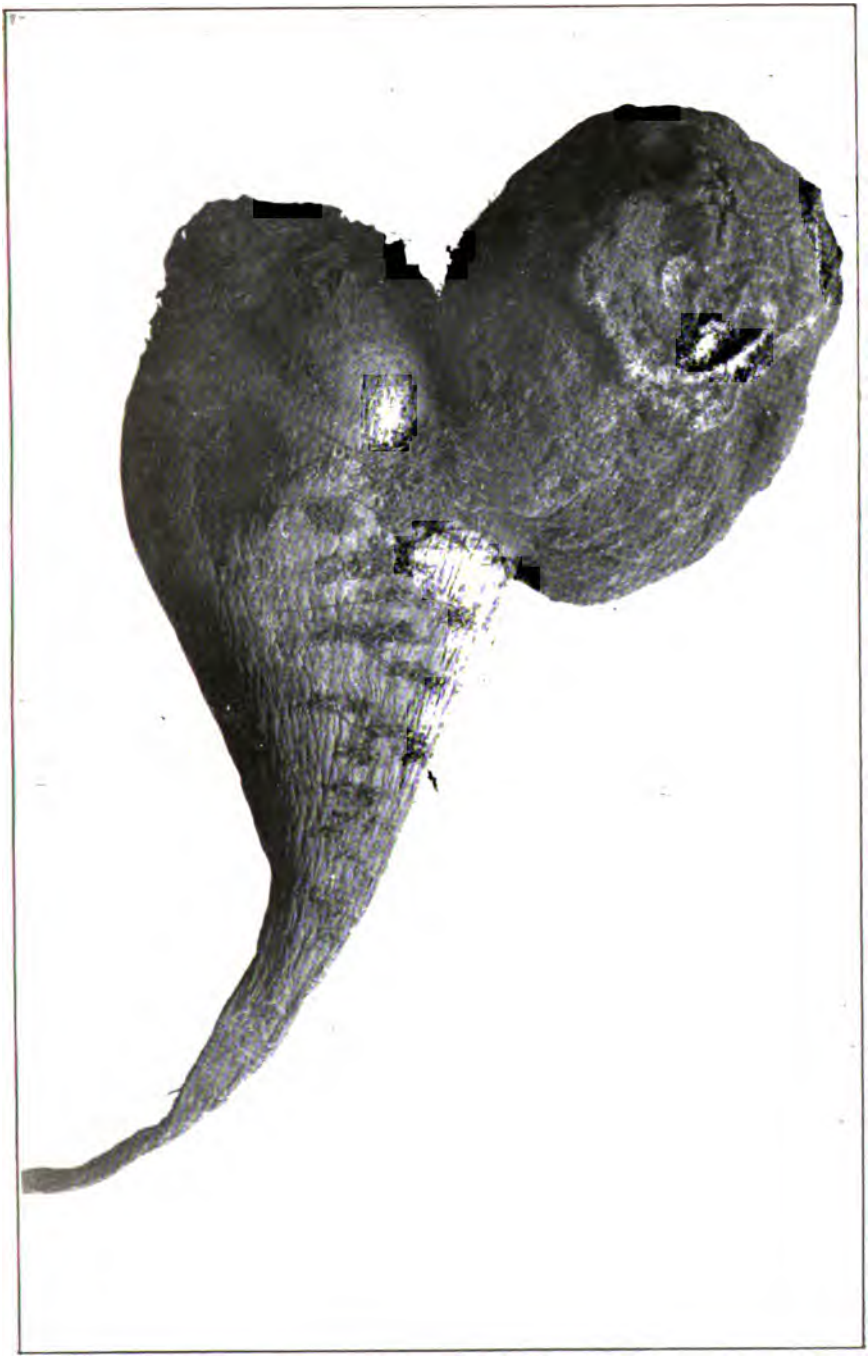
ROOT GALL.

This disease, known for more than fifty years in Germany, has appeared in a few of the beet-growing sections of this country. The galls usually form upon the upper part of the root, sometimes one, sometimes several, upon the same root. One large gall, typical in position and appearance, is shown in Pl. XV. These outgrowths vary in size from that of a pea to 6 inches or more in diameter. When the galls have once started they continue to increase in size with the age of the beet. Although this disease has received considerable attention from several investigators, the cause of the trouble has not been definitely determined. By some investigators it has been ascribed to the action of insects, while others hold that it is due to the presence of fungi, and still others think it is due to unfavorable conditions of soil and climate. The result of this disease is to reduce the size as well as the quality of the affected beets. Experience shows that beets grown in soil where the disease has previously appeared will be affected usually more seriously with each succeeding crop, hence rotation should be practiced wherever the root gall appears, at least until the matter can be further investigated and some satisfactory remedy found. It should be stated that rotation is not always necessary nor desirable.

CONCLUSIONS.

The main problems which present themselves to the grower of sugar beets from the standpoint of disease lie along the line of prevention rather than cure. Prevention must be considered from two standpoints: First, the prevention of the introduction of diseases from other beet-growing countries; second, the prevention of the annual attacks of diseases already established in the beet fields of our own country. It is possible that diseases may be introduced from foreign countries through the importation of foreign seed, and it would be very desirable if all sugar-beet seeds could be treated for the destruction of fungous spores before planting. The seeds should be treated by the growers themselves or by some competent person just before the seeds are planted. While it is true that the proper treatment of the seed balls with suitable fungicides will greatly diminish the possibility of the introduction and dissemination of disease through the agency of seeds, the most satisfactory fungicide to be used for this purpose has not yet been clearly established. Investigations are now in progress along this line. It is necessary that the fungicide employed should be effective in destroying the spores without injuring the germinating power of the seed, that it should be inexpensive, and that it should be of such a nature as to be easily and safely used by the grower. Various forms of fungicide, such as copper sulphate, carbolic acid, formaldehyde, lysol, sulphuric acid, etc., have been used in the treatment of beet seed by different investigators with varying results. In most instances a 1 per cent solution of carbolic acid seems to have been reasonably satisfactory from the standpoint of spore destruction, but the objection raised against it is that it is too expensive for practical purposes. The same objection is made to some other fungicides. Again, while some substances are inexpensive, they are often but partially successful as spore destroyers or are injurious to the seed.

In efforts to prevent the attacks of prevailing diseases of the sugar beet from year to year, several methods present themselves, all of which may be useful: (1) The seed should receive consideration, whether grown at home or abroad; (2) conditions point to the importance of producing varieties of the sugar beet that shall be resistant to at least some forms of disease; (3) the treatment of the foliage is of prime importance, especially in those sections where leaf spot and other diseases of the foliage produced by parasitic fungi are prevalent; and (4) the treatment of the soil should receive careful and prompt attention. This is placed last not because it is considered of least importance, for in some sections it is all-important. Indeed, it is of more or less importance, either directly or indirectly, in the consideration of diseases wherever sugar beets are grown. The same treatment,



SUGAR BEET WITH LARGE GALL.

however, can not be established for all places, even where the same disease occurs. Sometimes it is a case of drainage, sometimes a case of irrigation, of fertilizers, of fungicides, of seed treatment, or of the development of resistant varieties. These are some of the problems that are at present confronting those who have in charge the investigation of the diseases of sugar beets. The results of these investigations will be made known to those interested in the growing of sugar beets as soon as definite conclusions are reached.

SUGAR-BEET SEED: PRODUCTION AND TESTING.

By A. J. Pieters, of the Bureau of Plant Industry.

In the case of no other crop is the success of large operations and the profitable investment of millions of capital more dependent upon the quality of the seed than in that of the sugar beet. European sugar producers have realized this for many years, and the American manufacturers are becoming more convinced of it every season.

IMPORTANCE OF USING FIRST-CLASS SEED.

The importance of using first-class seed has been so well brought out by Henry W. Diederich, consul at Bremen, Germany, in Consular Reports, No. 242, that I can not do better than to quote a part of his report:

> Sugar is made not in the sugar factories but out in the fields. Therefore, it is impossible to pay too much attention to the cultivation of beets containing the highest proportions of sugar, and, at the same time, with the largest tonnage per acre. In order to produce such, the selection of suitable soil, the climate, the rainfall, and length of season, the fertilizing and planting, the cultivating and harvesting—all are very important factors. But the most important of all is to start out with the best seed obtainable; for good seed, after all, is the foundation of successful sugar industry. If I may express an opinion, based on my personal observation, it is that some of our beet growers should insist more than they have upon getting none but the best of seed, no matter what the price may be. * * * The first-class sugar factories of Europe buy none but the very best seed, grown from high-grade individual "mother" beets, to distribute among the beet growers; thus not only maintaining the standard of their sugar beets as to quality and quantity, but also putting themselves in a position to compete in all the markets of the world. This first-class seed is sold and delivered by the growers on board cars in the Prussian province of Saxony at from 8 to 10 cents per pound, which is a moderate price, considering the fact that it takes at least four years to get it into the market.
>
> There is also a second-class seed offered for sale in this country at from 5 to 6 cents per pound. This is commonly called the "nachzuchtsamen," being a seed produced not from the mother beets, but from the first-class seed mentioned above. This inferior grade, however, is not used by first-class sugar men in Germany, France, Holland, and Belgium, but most of it goes to Austria, Russia, and the United States. And this is the reason why I deem it my duty to call attention to the importance of getting only the very best seed obtainable. In my opinion, those American growers of sugar beets who buy cheap grades of seed make a great mistake. All kinds of

[illegible] tendency to degenerate. Even the first-class beet seed [illegible] beets that come up to the standard of the [illegible] a loss of one-half to 1 per cent of sugar content. [illegible] seed will degenerate more than as much again, and [illegible] small amount, when considered by itself, yet it is [illegible] sufficient to turn the profits of a sugar factory into a loss, but even to drive [illegible].

[illegible] Factory A slices 50,000 tons (short) of beets, which would yield [illegible] per cent sugar in the extraction. After deducting the sugar [illegible] and other waste, this would leave about 13 per cent—6,500 [illegible] marketable sugar, which, at $50 a ton, would net $325,000.

[illegible] slices the same amount of beets, grown from second-class seed, which, [illegible] have a yield 1.5 per cent less of sugar in the extraction. After this [illegible] has gone through the process of refining there will be 11.7 per cent—[illegible] marketable sugar, which, at $50 a ton, would net $292,500.

[illegible] see at a glance that, while both factories use the same amount of mate-[illegible] and have the same expenses for labor, fuel, etc., there is a difference in the gross [illegible] of refined sugar amounting to $32,500.

Factory A bought 50 tons of first-class seed, at $180 per ton, $9,900; Factory B [illegible] 50 tons of second-class seed, at $120 per ton, $6,600. It will be seen that Fac-[illegible] "economized" and to make money fast. It did, indeed, save $3,300 [illegible] season. But Factory A began by planting the very best seed obtainable, and came [illegible] season with $29,200 cash ahead of its competitor, and was in the [illegible] enjoying a handsome dividend.

[illegible] things in life, the cheapest beet seed is the dearest. It pays to [illegible] best, and only the very best is good enough. Let the good work of [illegible] in the field of sugar-beet culture continue, in order to learn exactly [illegible] can do in the face of fierce and growing competition; but let American [illegible] determine not only to try different varieties of seed, but also to plant none [illegible] seed of high grade and pure pedigree.

It is evident that, if the profitable operation of a sugar factory may depend upon a difference of 1 per cent in the sugar content of the beets, it is of the utmost importance that the seed used should be the best obtainable and that it should also be adapted to the climatic and soil conditions obtaining in the sugar belt of the United States. At present almost all the sugar-beet seed used in the United States is imported from Germany, only a small amount being grown in this country. Judging from the acreage that it is estimated will be planted in sugar beets in 1902, about 2,400 tons of seed will be required. Of this amount less than 100 tons will probably be produced in the United States, the greater part of that in Colorado and California.

The price paid for imported seed varies from 7½ to 17 cents per pound, the average price paid by most factories being about 9 cents, delivered in Chicago or Omaha. It costs in the neighborhood of 4.5 cents to grow a pound of sugar-beet seed in France or Germany, but chiefly because of the greater cost of labor in the United States domestic seed can not be sold as cheap as foreign, California growers receiving 10 cents per pound, exclusive of freight charges.

EXPERIMENTS WITH IMPORTED AND HOME-GROWN SEED.

Some years ago the United States Department of Agriculture established a station for growing beet seed at Schuyler, Nebr., where 5,000 tested mothers were planted in 1893. The station being abandoned, the seed produced was sold to the highest bidder. Several experiment stations have also done more or less work along this line, the stations in Colorado, Nebraska, Illinois, Indiana, and Minnesota being at present actively engaged in this work. At the Colorado station the tests made with imported and domestic seed resulted favorably to the latter. The results of these experiments are given in Bulletin No. 51 of the Colorado Agricultural Experiment Station, from which we quote:

An extensive series of tests was made of beet seed grown in the United States as compared with seed grown in Europe. Six varieties were used; one grown in France, one in Saxony, two in Germany, and two in the United States. The sources of the seed are as follows:

1. Utah Kleinwanzlebener: This seed was grown at Lehi, Utah, by the Utah Sugar Company. The seed first used was the Original Kleinwanzlebener, from Germany, and the seed tested this year was the second generation of American seed grown from the German seed.

2. Original Kleinwanzlebener: Imported from Germany and sent to us by the Utah Sugar Company. Of course this was not the identical seed that was used as the ancestor of the Utah Kleinwanzlebener seed above mentioned, but it is from the same seed farm, of a crop a few years later, and is presumably of about the same quality.

3. Vilmorin: Sent us by the United States Department of Agriculture and imported by them from the original growers in France.

4. Mangold: Grown by M. Knauer, Groebers, Saxony, and imported for us by the agent, H. Cordez, Lagrande, Oreg.

5. Eddy Kleinwanzlebener: This seed was grown at Eddy, N. Mex., during the season of 1897, from the beets of 1896, that were grown from seed obtained from Maison Carlier, Orchies, North France. It is, therefore, the first generation of American seed from the original French seed. This is the first crop of seed raised at Eddy.

6. Elite Kleinwanzlebener: Imported from Germany by the United States Department of Agriculture. Seed of these six varieties was sent to quite a number of persons in the various irrigated portions of Colorado who had promised to take special pains in the test. Some of the tests were to be on a small scale with the richest of ground and the best of conditions. Another set of tests was to be made on a larger scale under general farm conditions.

The results of the experiments are tabulated, and the conclusions drawn from these are as follows:

A comparison of the results from the different kinds of seed shows, first of all, that they are all good seeds. An average of 25.1 tons of beets per acre, testing 15.57 sugar and 81.3 purity, is a very high yield. There is, however, considerable difference in the results from the different varieties. The Elite Kleinwanzlebener and the Vilmorin were sent us by the United States Department of Agriculture as the best beet seed that they could get. The original Kleinwanzlebener was selected by the Utah Sugar Company as, in their judgment, the best brand of seed on the market from which to raise their own seed. If we take the average of these three first-class seeds and compare it with the seed raised in Utah, the comparison is in favor of the Utah-

grown seed in per cent of sugar and purity, while the crop per acre is equal. The Utah seed is therefore superior in pure sugar per acre and in available sugar per acre. The Utah seed is superior to the seed from which it is descended in sugar and purity, but a little inferior in quantity of crop.

The seed grown at Eddy does not give so good results as the Utah seed, but it equals the Vilmorin and is not far behind the Original Kleinwanzlebener. The germinating quality of the seeds is quite satifactory. The four Kleinwanzlebener varieties give 87 per cent of stand, while the Vilmorin gives 80 per cent and the Mangold 75 per cent.

In the light of these experiments there can be no doubt that sugar-beet seed can be grown in the United States fully equal to the best of the imported seed.

In the experiments at Scuyler it was shown that the domestic seed gave crops of 21.1 tons per acre, while the imported seed gave but 17.9 tons, and that the amount of sugar produced per acre was 12 per cent greater from the domestic than from the foreign seed.

PRODUCTION OF SUGAR-BEET SEED IN AMERICA.

The beet seed grown by private enterprise in Colorado and California is all used at or near the place of production. That the seed produced gives satisfaction is abundantly attested by the fact that the growers are increasing their acreage as rapidly as possible. The Utah Sugar Company of Lehi, Utah, which began to grow seed in a small way some years ago, produced 40 tons in 1900 and had an increased acreage in 1901. J. B. Agnew, a seed grower of Agnews, Cal., produced 25 tons in 1900. So far, wherever home-grown seed has been used in comparison with imported the sugar content of the resulting beets has been higher than that from imported seed. In Washington State, where the production of sugar-beet seed has recently been begun, the results have been especially striking, as will appear from extracts from a letter written by E. H. Morrison, of Fairfield, Wash. Mr. Morrison sent samples of home-grown and imported seed to be tested for germination. The results of the tests showed that the domestic seed had much better vitality than the imported seed.

Tests of imported and home-grown seed.

	Domestic.	Imported.
Percentage of purity	96.12	90.9
Sprouts from 100 balls in 6 days	191.5	100.
Sprouts from 100 balls in 12 days	197.5	112.
Percentage of balls sprouted in 6 days	93.	53.5
Percentage of balls sprouted in 12 days	93.	53.5
Sprouts from 1,000 grams of seed in 6 days	114,600	71,000
Sprouts from 1,000 grams of seed in 12 days	119,000	80,800

Regarding this seed, Mr. Morrison said:

Of the two samples sent you, the one marked "No. 1" was home-grown crop of 1901. Sample No. 2 was Kleinwanzlebener Original, said to be the best imported seed of the crop of 1900. The seed marked "Domestic" was grown from beets of Kleinwanzlebener Original seed. The physical selection of the mothers was made by

my foreman, who has had, as I said above, twenty years' experience in seed raising in Europe. The selections were made with great care from a field of 120 acres that gave an average factory return of 20 per cent sugar and a purity coefficient of nearly 90, many individual beets showing 24 per cent of sugar.

The beets I raised this year from my own seed, for the Waverly factory, gave me an average factory return of 19.9 per cent sugar and a purity of 88. The beets in the same field from Germany, Kleinwanzlebener Original, averaged 18.59 per cent sugar and 85.67 in coefficient of purity.

My experience indicates that this section of Washington is well adapted to growing beet seed of a superior quality. In the first place our beets generally have a high percentage of sugar and purity. Then, again, we have a long, warm, cloudless summer for the maturing of the seed. So far my average has been about 1,500 pounds of seed to the acre. I think by the use of fertilizers and better preparation of the soil, and with a favorable season, that this could be increased to 2,000 pounds per acre. * * *

I inclose copy of analyses of beets sent by me to Professor Fullmer, of the Pullman Agricultural College, in 1895, simply to show the purity of the beets grown in this vicinity, which certainly should enter as a factor in producing high-grade seed:

Results of analyses of beets grown in Washington.

Weight of beets.	Sugar in beets.	Sugar in juice.	Coefficient of purity.
Ounces.	*Per cent.*	*Per cent.*	
11	22.4	23.6	92.9
11	21.9	23.0	93.1
14	20.6	21.7	93.5
13	20.1	21.2	92.2
25	19.9	20.9	86.7
14	19.5	20.5	90.7
30	18.6	19.6	94.2
20	18.2	19.2	90.1
24	18.0	19.0	89.6
16	17.3	18.2	85.4
23	17.1	18.0	92.3
18	16.9	17.8	92.2
17	16.5	17.4	88.3
16	16.3	17.1	87.7
16	13.8	14.6	88.5

The beet-sugar industry is now so well established in the United States that it would be poor policy to depend longer on imported seed. The possibility always exists that by failure of the crop or by reason of political or trade disturbance the supply of seed may be cut off; but even if this possibility be regarded as remote, it is nevertheless true that American sugar factories will never attain their maximum profit until we have beet seed especially produced to meet American conditions. The problem which the Department of Agriculture will seek to solve is where sugar-beet seed may be grown to give the best results under the varying conditions prevailing throughout the sugar-beet belt. Experiments have been undertaken for the production of sugar-beet seed in cooperation with the State experiment stations. These experiments will be conducted according to the best commercial methods

and on a scale sufficiently large to throw light on the problem of beet-seed production in the United States.

TESTING SUGAR-BEET SEED.

Only second in importance to the care with which a strain of beet seed has been selected is the vitality of the seed. The matter of testing beet seed for purity, moisture content, and germination has therefore received a great deal of attention abroad, and one of the chief duties of the seed control station is the testing of sugar-beet seed. Standards have been adopted by a number of societies and stations, but, of these, two are the most important—the Magdeburg standards, which are in use throughout Germany, and according to which American factories usually buy, and the Vienna standards, which are maintained by the Government experiment station at Vienna, Austria, and are in force throughout the country. When seed is sold subject to either standard and fails in any particular, it may be refused. These standards are, however, not adequate protection for the American buyer, so long as he must use imported seed. The ocean voyage always has an injurious effect on the vitality. Seed that left Germany up to grade may not show standard test when delivered in the United States, and it is difficult in case of a difference between the first and second test to effect a settlement. With home-grown seed such trouble would not be experienced, differences could easily be adjusted, and there would not be, for many years at least, a temptation to sell old seed for new, because the demand will for a long time exceed the supply. The methods in use in the seed laboratory of the Department of Agriculture are identical with those used by the best German stations. The balls are soaked for about six hours and are then placed between blotters wet with filtered water. They are then put in chambers where they are kept for six hours at a temperature of 40° C. and for eighteen hours at 20° C. The first count is made after six days and this is reported as the preliminary report. The test is completed in twelve days.

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